RESTRICTED



# POLAR GUIDE

DEPARTMENT OF THE AIR FORCE

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U.S. Air Force. Air Transport Command



# POLAR GUIDE

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U.S. DEPARTMENT OF THE AIR FORCE

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# CHARACTER OF THE COUNTRY

# PART 1

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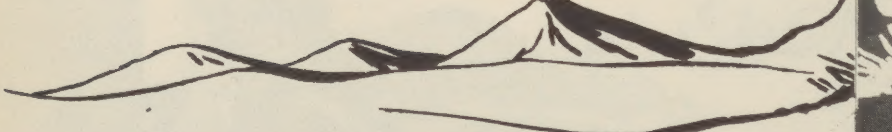
The average man thinks of the Far North as a region of unendurable cold, covered permanently with ice and snow, and inhabited by a few Eskimos and polar bears.

Actually, the polar regions are quite different from this conception. It is cold in many parts of the Far North, but there are parts that are warmer than many places in the United States. Some areas are covered with ice and snow the year around, but others are covered with forests and meadowlands, flowering plants and a great variety of trees. Polar bears do inhabit a good part of the Far North, but so do rabbits, birds, goats — and even mosquitoes.

Many kinds of country make up the polar regions, and many kinds of climate are found up there. Some parts of the country may well resemble the areas around your home town a good part of the year. Others will be more like places you have read about but have never seen. You will find some animals and plants you know and some you've only seen pictures of. In short, you will find a great deal that is familiar and also a great deal that is strange in the polar regions.



CHAPTER 1

# GENERAL

## REGIONS

While most observers agree in dividing the Far North into two regions—the polar and sub-polar regions—the exact basis for the division varies because the exceptions to any system of division are so numerous that none can be absolutely consistent.

The most common basis for distinguishing between the regions is temperature. Generally, those parts of the Far North in which the mean annual temperature is 32° F or less and the mean temperature for the warmest summer month is less than 50° F are considered the polar regions, while those regions of the Far North which are warmer than this are considered the sub-polar regions. However, mean temperatures are misleading, for in some areas, such as the Aleutian Chain, the summer temperature is low, and the mean annual temperature is low despite relatively warm winters. At the same time, at Fort Yukon, Alaska, where the winters are among the most severe throughout the Far North, the mean annual temperature is relatively high because of hot summers.

Another method of distinguishing between the polar and the sub-polar areas is by the northern limit of the forest (shown on the maps in back cover). However, here too there are regions such as the Aleutians where there are no trees at all but which are definitely part of the sub-polar area. Still another basis for establishing a line of demarcation between the polar and sub-polar regions is the polar front, but to this basis also there are numerous exceptions.

In general, the polar region includes the northern coasts of Alaska and Canada, the Canadian Arctic Archipelago, much of Labrador, and most of Greenland. The sub-polar region, a belt of variable width south of the polar region, includes Newfoundland, southwest Labrador, the interior of Alaska, and most of the interior of Canada. For purposes of description, the polar region can be divided into the land areas and the sea areas (or rather the areas of ice pack), while the sub-polar region can be considered as sub-divided into a coastal and an interior area.

Remember, however, that while these general divisions are useful for an overall bird's-eye view of the Far North, their value in specifying the climate and characteristics of any particular local area is almost negligible because of the manifold exceptions to the rules. The areas you will be particularly interested in—Alaska and the polar ice pack—are therefore discussed in Chapter 2, LAND AREAS, and Chapter 3, WATER AREAS, respectively.

### DESCRIPTION

Most of the sub-polar region, with a few exceptions, is heavily forested. The polar region, on the other hand, has no forests. Aside from the shrub willows which are common there—in some places they grow in clumps seven to eight feet high—the polar region is characterized by vast stretches of mucky, treeless land covered with a variety of plants, including grasses, lichens, and shrubs. This type of country is called tundra. Unlike prairie country which it generally resembles, tundra is, to a large extent, poorly drained and marshy.

Most of the tundra and parts of the forested sub-polar region are permanently frozen a few feet beneath the surface. During the summer, the ground thaws to a depth of a foot or more, but because of the underlying frozen ground, water cannot sink below the thawed layer. Consequently, the ground is kept moist in most places. Frozen ground is thus responsible for marshy character of the tundra and for the poor drainage of large parts of the Far North. It is also partly responsible for the many lakes.

### GLACIERS

There are glaciers in many parts of the Far North. They occur most frequently at or near mountains, for there the rain and snow are normally greatest. Basically there are two types of glaciers—ice caps and valley glaciers.

Ice caps, as their name implies, cover large areas of land without regard to the underlying topography. An outstanding example is the Greenland ice cap, the largest in the Northern Hemisphere. Much smaller ice caps cover parts of Baffin Island, Bylot Island, Devon Island, and Ellesmere Island, in the eastern part of the Canadian polar regions. The western part of the Canadian polar regions is fairly flat and free of ice caps. The glacier covered southern portion of Kenai peninsula is a good example of the domed ice cap found in Alaska.

Valley glaciers are essentially rivers of ice confined to valleys. A valley glacier may be an independent unit or it may be connected with an ice cap like a stream with a lake. Such are the valley glaciers emanating from all around the Greenland ice cap. Valley glaciers occur wherever there are ice caps. They are also found in the mountains of Alaska and the Yukon.

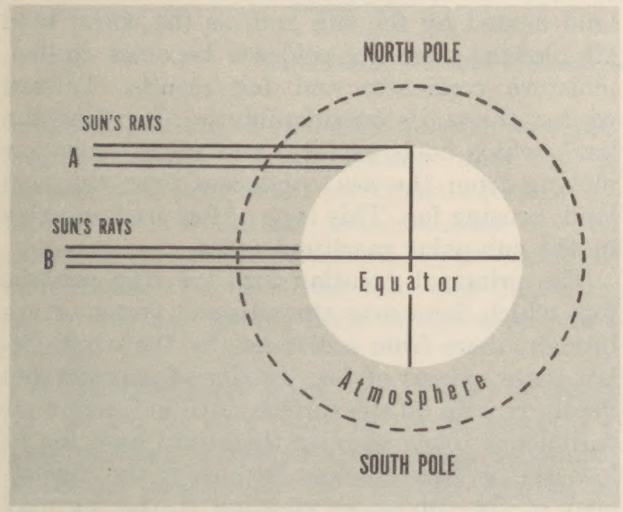
All glaciers move with a slow-flowing motion, some exceedingly slowly and others at rates of tens of feet a day. The slow-flowing movement of the ice deep in the glacier causes great gaping cracks to appear in the brittle surfaces of both ice caps and valley glaciers. These cracks are called crevasses. Generally speaking, the steeper the slope and the more irregular the bed of the glacier, the greater the profusion of crevasses. There are often snow bridges across crevasses, but these are frequently too weak to support a man's weight and are therefore dangerous. (Suggestions for glacier travel are on page 18-41.)

### CLIMATE

A major factor in the climate of any region is the amount of heat the region receives from the sun. This amount depends chiefly on the angle at which the sun's rays strike the earth and the duration of the sunlight. The farther north you go, the less directly the sun's rays strike the ground and the weaker is their effect. Consequently, the polar region has the lowest mean annual temperature in the Northern Hemisphere. This does not mean, however, that there are no places with colder temperatures. Local conditions, such as wind, topography, and proximity to large bodies of water, also have an appreciable effect on temperature, and therefore, the coldest spot in the Northern Hemisphere is not in the polar region, but in the sub-polar region more than 200 miles south of the Arctic Circle. As a matter of fact, even in the United States, temperatures in Wyoming,

Montana, and North Dakota are sometimes lower than any usually encountered in the polar region. Temperatures that would be considered high even in Florida are also common in the polar and sub-polar regions. Temperatures of 80° F in the shade have been recorded frequently in many places, and a record of 100° F in the shade has been set at Ft. Yukon, Alaska, on the Arctic Circle.

Temperatures vary considerably in the regions of the Far North, but in general, the sub-polar interior area has the coldest winters and the warmest summers. The sub-polar coastal area has warmer winters and cooler summers because the large bodies of water there stabilize the temperatures. The polar region is quite cold the year around.




***Ray A delivers less energy at the earth's surface than ray B because its energy is spread over a greater area and because it passes through a thicker layer of atmosphere.***

Mean temperatures for the warmest and coldest months probably give the best picture of the weather situation. In the region of the polar ice pack, the mean winter temperature is about −30° F, while along the north polar coastal areas it is about −20° F. The interior of the continent has far colder winters. While the mean varies from about −11° F to about −21° F, the minimum often is as low as −50° to −60° F, and has gone below −80° F near the Alaska-Yukon border. In the sub-polar coastal areas and in the Aleutian Chain areas the winters are mild with means varying from 16° to 36° F, depending on the locality.

Comparing these temperatures with the mean January temperature of 9° F for Bismarck, N. D., and even 13° F for Minneapolis, Minn., you can readily see that some places in the Far North are warmer in the winter than many places in the United States.

During the summer months the temperature on the polar ice pack stays fairly constant at 32° F. In the Aleutians it varies from 43° to 49° F, while in the sub-polar coastal areas it varies between about 49° and 57° F. The warmest summers in the Far North are in the interior regions, where the mean is about 60° to 61° F—wonderful summer weather, you'll admit.

Thus, the idea that the Far North is terribly cold the year around is a fallacy.

## PRECIPITATION

Precipitation is generally very light throughout the polar region, ranging from 14 to 18 inches in southern Baffin Island and from 5 to 10 inches over the rest of the polar region. Approximately half of this falls as snow, which has been known to occur in any month of the year. (Ten inches of snowfall is approximately equal to one inch of rainfall.) This low precipitation (but still higher than Phoenix, Arizona, with a mean annual precipitation of 7.6 inches) is chiefly due to the fact that at the prevailing low temperatures, the air cannot hold much moisture. In addition, most bodies of water in the polar region are covered with ice a good part of the year, and the winds cannot pick up by evaporation the amount of moisture they can normally obtain from an ice-free sea.

The sub-polar interior area is also relatively low in mean annual precipitation, with a general variation of 10 to 20 inches. In the Aleutian Chain, however, precipitation is high, ranging from 29 to 76 inches. (At Mobile, Alabama, the mean annual precipitation is 60.7 inches.) On the average, precipitation in the Aleutians falls from 290 to 348 days a year. In the sub-polar coastal region, the total precipitation is even higher, varying from 15.5 to 230.5 inches, but the number of wet days is fewer, varying from 91 to 256.

## WINDS

The strongest winds on record are not in the polar region, but on Mt. Washington, New Hampshire, where gusts of 230 miles per hour have been recorded. Nevertheless, there are a number of regions in the Far North that are

quite windy. One region in which the wind is particularly severe is in the Aleutian Chain, which is on the main storm track and frequently has wind velocities in excess of 100 miles per hour. About 80 times annually the Aleutians experience gales (32 miles per hour or more). The most dangerous type of wind in the Aleutians is the *williwaw*, which is a strong mountain wind resulting from damming up of air on windward slopes followed by a highly gusty overflow down leeward slopes reaching hurricane velocities. Fort Glenn has reported velocities of 135 miles per hour with estimated gusts up to 150 miles per hour.

Another type of gustiness that occurs in the Aleutians is connected with the southeast and east quadrants of the approaching cyclone and the meteorological phenomena which occur in these sections of the cyclone. While the mountains of the various islands play an important part in blocking the free flow of air, this type of wind has similar characteristics even over the open sea. It is therefore not a real williwaw and should not be called that.

In the sub-polar coastal areas, winds are often severe with gales occurring during all seasons. Here, of course, because of the varying exposures and terrain features, there is great variation in the direction and intensity of the wind. While gales occur during all seasons, they are most severe in the fall, winter, and early spring.

The land areas of the polar region have some strong winds and gales during the late fall and winter months. Over the polar ice pack all seasons tend to be stormy, and in some parts high winds are the most noticeable feature of the climate. Here the summer season is the most hazardous, for the storm activity extends further due to a greater altitude.

The sub-polar interior region suffers the least from winds.

Of the various effects of the wind in the Far North, one of the most important is its acceleration of the rate of cooling. In assessing the cold weather problems of any region, therefore, wind as well as temperature must be taken into consideration. Thus, for example, while the temperatures in the Aleutians are mild compared to those in the rest of the polar region, the high winds in the Aleutians increase the rate of cooling to a degree that frequently makes the weather there more uncomfortable than in regions which are much colder but calm. To describe the combined cooling effect of wind and temperature, a new term—*wind-chill*—has been coined, and statistics are being gathered in order to make possible accurate evaluations of various combinations of wind and temperature.

### FOGS

Fogs are a great menace in the Far North. The number of clear days at Alaskan bases is seldom over half the total number and often less than one third. Nearly all bases, except those in the interior, average more cloudy than clear days in the course of a year. The greatest number of clear days occurs in the interior, especially during the late winter and early summer months.

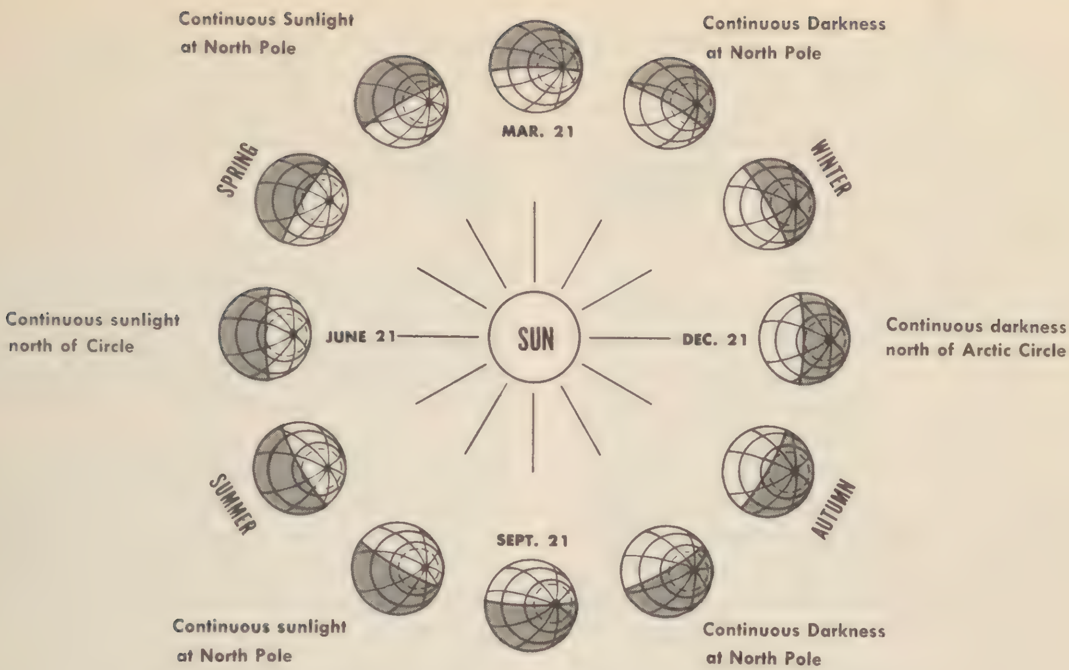
As in the rest of the world, the most common type of fog is the *coastal* fog that often lies in a belt parallel to the shore. In the summer months the sea is much colder than the dark land heated by the sun and, as the warm land air blowing over the cold sea becomes chilled, moisture condenses and fog results. Toward winter, the sea is considerably warmer than the land, which cools rapidly, and warm moist air moving from the sea condenses over the cool land, causing fog. This type of fog predominates in the sub-polar maritime areas.

The principal Aleutian fogs are true *sea-type* fogs which form over the adjacent water or are brought there from a distance by the wind. Often these masses of fog, usually of considerable depth, remain on the surface until increasing air turbulence tends to raise them into high fog or low stratus. Nevertheless, because of the consistency of the conditions creating it, the fog may continue at the surface for a long period, even when there are strong winds of gale velocity.

Over the polar ice pack, summer is the time of heaviest fog, averaging 2 days out of 3 in July and 1 out of 2 in June and August. It must be noted, however, that since these statistics are based chiefly on observations from the air, low stratus clouds may have been mistaken for fog.

The most common types of polar fogs in the winter are the *spicule*, the *ice*, and the *man-made* fogs. Spicule fog is formed of extremely fine ice crystals and is a kind of snowfall that results from the condensation during cloudless periods of low temperatures, high humidity, and calm or mild winds. At times it obscures the ground and makes flying extremely hazardous. Spicule fog is characteristic of the Greenland ice pack.

A similar type of fog is the ice fog which may occur in any area subjected to extremely low




*Relationship between seasons and sunlight in the Northern Hemisphere.*

temperatures but is peculiar to the northern interior regions. Ice fog, unlike other fog, is composed of very small ice crystals formed by sublimation. When less dense, the ice crystals glisten in the sun or moonlight. Upon becoming more dense, the particles lose this glistening appearance and ice fog takes on the appearance of other fog.

A closely related type of fog, caused by moisture in the air as a result of the presence of a large number of people, animals, or moisture-producing installations, is variously referred to as *man-made*, *human-animal*, and *town fog*. Over large installations it may persist over long periods of time and may restrict visibility to such an extent that aircraft operations are curtailed for periods of 2 weeks or longer. (One period at Ladd Field lasted for 22 days.) Generally, however, this type of fog soon "burns off" when the sun appears.

## SEASONS

In the polar regions, the sun shines for a very large part of each day in the summer and for only a very small part of each day in the winter. This means that there is a vast difference in the temperature of the polar regions between the summertime and the wintertime. Summer and winter with their extremes of temperature are consequently well marked. Autumn and spring are indefinite.

Spring merges into summer with the general melting of the snow, the more or less complete break-up of ice on rivers and lakes, and the appearance of flowers and numerous birds. Shortly after summer begins, sea ice starts to break up along polar coasts—permitting maritime navigation in many places. By August, about three-fourths of all land north of the Arctic Circle has become free from snow. Most of the remaining snow and ice is in the interior of Greenland; however, parts of Baffin Island, Devon Island, and Ellesmere Island are also ice covered. Compared with other seasons, summer is characterized by a profusion of plant and animal life on the land, and by open water in the seas. Continuous daylight during early summer is a notable feature of far northern latitudes.

Summer merges into autumn when birds start south, when temperatures drop to near freezing at night, and when the weather becomes unsettled and snow flurries appear. A little later, sub-freezing temperatures become common. Lakes freeze over, then streams, and finally the bays and inlets along polar coasts. By this time, the days have become short and there is some snow on the ground. During the freeze-up when ice is forming on lakes and sea, there is generally little sledge travel or seaplane flying. When temperatures stay low, when snow whitens the landscape, and when ice thickens over most of the Arctic Ocean, autumn merges into winter.

Winter is dominated by the persistent cold which controls all activities, and by the long nights. South of the Arctic Circle, and hence over much of the sub-polar region, the sun appears above the horizon every day. Above the Arctic Circle no sun should appear on December 22, but mirage effects may make the sun visible from as far as sixty miles north of the Circle.

Late winter merges into early spring with increasing hours of sunshine. Low temperatures are not uncommon and stormy winds may prevail at times, but the weather gradually turns milder and snow starts melting on land. In fact, melting starts even while the air temperature is below freezing. Because of radiation effect, dark objects can absorb enough heat from the sun's rays to thaw long before the ambient temperature is 32° F. Flowers sprout, at times through drifts, and seals take sun baths along polar coats. The land is gradually freed from snow, birds arrive, rivers break up, lakes open, and finally summer is at hand.

## UNIQUE FEATURES

Temperatures of $-30°$ to $-60°$ F have some curious effects. One of them is to dry the air. The colder air becomes, the less moisture it is able to hold. The inability of cold air to hold moisture causes condensation of your breath, and, even in more southerly latitudes, commonly forms a white fringe of frost on your eyelashes, your beard if you have one, and around your parka hood. Bodies of open water that are ice cold (but still warm in comparison with $-40°$ F) generate clouds of mist. Such clouds, rising from flooded rivers or from open water (leads) in an ice-filled sea, resemble the smoke of forest fires and are called *sea smoke* or *steam* fog. Animals and power vehicles also leave trails of fog behind them.

If the effects of condensing moisture are eliminated, cold greatly improves visibility, and you can see farther than normally. However, this makes it difficult to judge sizes and distances correctly, especially in places where there are no houses or trees to serve as a scale. The cold also affects your hearing. Sometimes, on a still day in the polar winter, you can hear the barking of dogs or the sound of an axe miles away and are likely to think you are nearer the source than is actually the case. On the other hand, the snow may so absorb sound that, in a snow cave, you may have to shout at the top of your lungs to be heard ten feet away.

The bending of light rays as a result of abrupt changes of temperature with increasing altitude causes many peculiar phenomena. The appearance, in the sky or on the horizon, of objects that are normally hidden below the horizon, is a common occurrence in the Far North. Images, sometimes upside down, may appear well up in the sky, resting on a pedestal or floating just above the horizon. These effects, known as "looming", are a particularly common form of mirage. The opposite may also happen, and nearby objects which should be in clear view disappear.

There are also the northern lights, sometimes referred to as the Aurora Borealis. These lights constitute one of the most interesting phenomena of the north polar regions. Although by no means confined to these regions, they are most noticeable here. When best developed, they appear in the sky as fluorescent bands of variously tinted light, constantly changing in shape and intensity. The light may appear at one time like an undulating curtain draped across the sky, then change to a luminous haze or to a number of bright darting shafts. Northern lights are sometimes only a faint glow in the sky, but at other times, in the areas of the greatest auroral intensity, they create as much illumination as the moon.

Winter is definitely not a period of total darkness. If you go far enough north, there will be no sunshine for many weeks. However, because of extreme surface temperature inversions, the rays curve so much that you often see the sun when it is really below the horizon. In addition, the particularly long periods of bright moonlight, the light from the northern lights and the stars, and multiplication of light by reflection from the snow make visibility far better than you would expect. On a bright moonlight night, for example, you can see a sledge track glimmering as far as a quarter of a mile away, and can recognize colors as far as 100 yards away.

CHAPTER 2

# LAND AREAS

**Detailed maps of the Far Northern areas of the Western Hemisphere are in the flap on the back cover of this manual.**

## ALASKA

As previously mentioned, the division of the Far North into polar and sub-polar regions is accurate only in a general way, for specific topographic conditions cause many variations in the character and climate of any particular area. This is true even when the general categories are smaller than those covered by the terms *polar* and *sub-polar*. Thus, while the divisions of Alaska described here are more nearly exact than the divisions under the headings *polar* and *sub-polar*, there are still wide variations within these regions. Nevertheless, it is possible to delineate four separate regions in Alaska: the Aleutian region, the Gulf of Alaska region, the interior region, and the North Bering Sea and Arctic region. These four regions differ considerably one from another and, at the same time, are each relatively homogeneous within themselves.

### The Aleutian Region

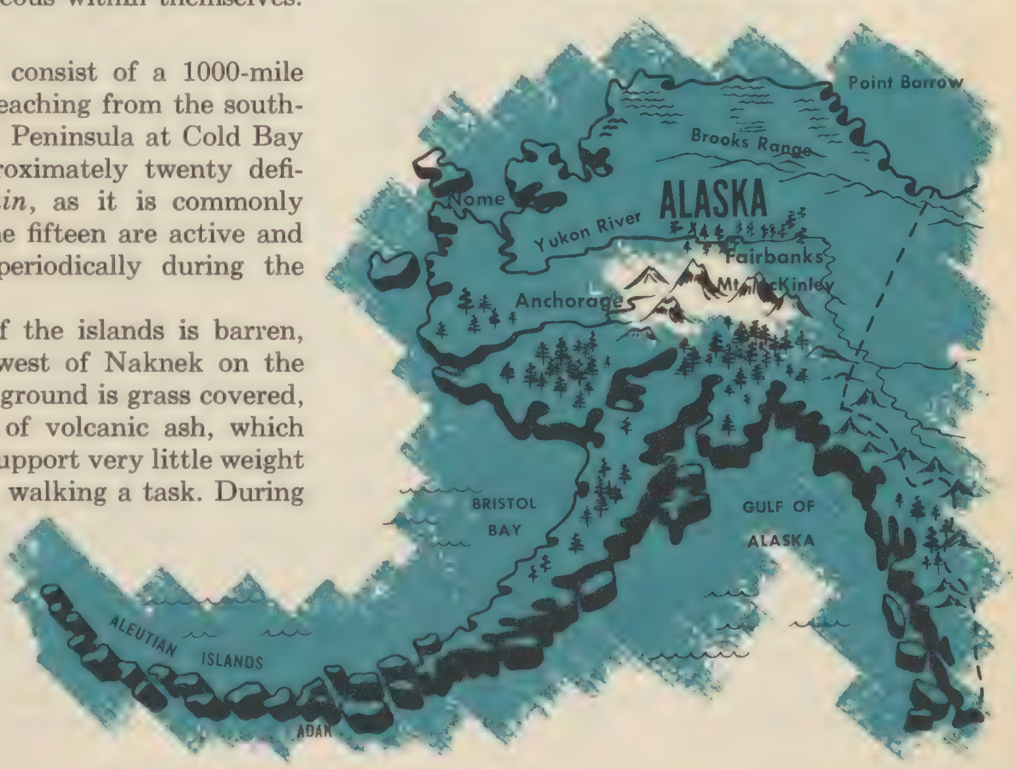
The Aleutian Islands consist of a 1000-mile arc of volcanic islands reaching from the southwest end of the Alaskan Peninsula at Cold Bay to Attu. There are approximately twenty definite peaks on the *Chain*, as it is commonly called, and of these some fifteen are active and smoke continually or periodically during the year.

The general nature of the islands is barren, no trees growing southwest of Naknek on the Alaskan Peninsula. The ground is grass covered, sodden muskeg on top of volcanic ash, which has little body and can support very little weight per square inch, making walking a task. During the summer season, this muskeg supports a green grass and many colorful flowers. During the remainder of the year it is the color of straw or snow covered.

The mountainous terrain has a barren beauty which is well appreciated during the few days of sunshine which occur each year. During the summer season, the snow melts off all but the highest mountains. It returns early in the fall.

The Aleutian Islands are cold, humid, and foggy, with a minimum of clear summer weather and with frequent cyclonic storms, heavy squalls, snow, and fog. They are particularly notorious for extremely rapid changes in weather conditions and simultaneous variations of weather from one locality to another.

The temperatures in the Aleutians are extremely stable, with daily and seasonal variations at a minimum. The mean temperatures for the warmest month—July—vary from 43° to 49° F, while those for the coldest month—January—vary from 30° to 32° F. While the mean annual precipitation is not particularly high—varying from 29 to 76 inches—precipitation is extremely



frequent, occurring, on the average, between 290 and 348 days a year.

One of the primary climatic features of the Aleutians is the high degree of cloudiness, largely in the form of low stratified and cumulus clouds. There are only a few clear days during the year for, in addition to the clouds, the Aleutians are frequently obscured by sea-type fogs. Peculiarly enough, these fogs persist even though the outstandingly severe weather element throughout the Aleutian Chain is the wind. Hurricane velocities (75 mph or more) occur on all the islands from 2 to 15 times a year, during all seasons. Gales (32 mph or more) occur about 80 times a year. Together with the high humidity, this combination of wind and low temperature produces an uncomfortable degree of "wind-chill", which makes the climate in the Aleutians quite disagreeable to many people.

Flying conditions in the Aleutians are probably among the worst in the world, for ceiling heights are below 1000 feet 20% to 40% of the time and visibility values are less than 3 miles 7% to 28% of the time.

#### Gulf of Alaska Region

The whole southern coast of Alaska, including the Alaskan Peninsula, is a rugged mountainous area with hundreds of islands, numerous mountains, indentations, straits, and waterways. It can really be divided into two areas, separated from each other by Mt. St. Elias and Mt. Logan. In general, it has a maritime climate with heavy precipitation and fog, cloudiness, and fairly moderate temperatures. However, because of the mountainous nature of the terrain that shelters some of the areas, there is considerable diversification of climate.

The Alaskan Peninsula is a mainland continuation of the Aleutian Islands and is much like the island arc in general character. Altitudes, however, are commonly greater. For instance, Iliamna Volcano and some other peaks are more than 10,000 feet high. The southern coast of Alaska has the most recent volcanoes but is even more mountainous than the Aleutian arc. The Kenai Mountains rise to more than 5,000 feet and Mt. Marcus Baker, in the Chugach Mountains further inland, is 13,250 feet in altitude. Further southeast, the St. Elias range boasts Mt. Logan (in neighboring Canada) and Mt. St. Elias with altitudes of 19,850 and 18,008 feet, respectively. The Gulf of Alaska also contains a number of glaciers, notably the Malaspina, the Hubbard, the Bering, and Taku.

In general, precipitation is frequent and abundant, rising well above the equivalent of 100 inches of rainfall (a good part of the precipitation is snowfall), with 200 or more wet days at all localities exposed to the sea winds. The percentage of sunshine is low in all parts of this region and, except in the localities protected by the mountains from the sea influence, the annual number of cloudy days exceeds the number of clear and partly cloudy days combined. Fog is frequent throughout the year, and is most prevalent in the summer. Because of the varying exposures relative to the sea, the inland waterways, and the terrain features, the winds in this region vary greatly in direction and intensity. One of the best known wind patterns in this area is known as the Taku Winds, which have their origin over the Taku Glacier and descend as mountain winds, often of intense velocity, through Taku Inlet across Stephens Passage, frequently accompanied by blinding snowstorms.

Flying conditions are poor in this area, with excessive precipitation, persistent low cloudiness, and fog formation producing icing, low ceilings and visibilities and causing frequent delays and cancellations of flights.

#### Interior Region

The interior region is a country of relatively low relief, consisting of flat-topped highlands separated by broad valleys and extensive muskeg lowlands. It contains most of the forested and agricultural lands of Alaska and is very rich in minerals. In general, this extensive area from Brooks Range on the north to the Alaskan Range on the south is continental in climate, with the coldest winters and warmest summers in Alaska.

Thus, in this area, summer temperatures of 100° F at Ft. Yukon, 99° F at Fairbanks, and 98° F at Ruby and Nenana have been recorded, while winter temperatures have dropped to −83° F at Snag, not far away. Precipitation is relatively light here, as are the winds. The snow that falls during the winter months generally disappears during the first three weeks in May, except in the timber and higher elevations. Fog is relatively infrequent, except for the ice fog previously described, which is prevalent during the winter.

Among the major features of this region are Mt. McKinley and the Yukon River. Mt. McKinley, with an altitude of 20,300 feet, is the crowning summit of the Alaskan region and the loftiest peak in North America. The Yukon River, about 2,000 miles in length, is one of the chief waterways of the world.

#### North Bering Sea and Arctic Region

Comprising roughly one-sixth of the area of Alaska, the polar area includes the area north of the Brooks Range inside the Arctic Circle, Kotzebue Sound, Seward Peninsula, Norton Sound, the Yukon and Kuskokwim Deltas, and the Bristol Bay area. Although temperatures in this region seldom fall below those in the interior region, and although during part of the summer this region has a more or less maritime climate, it is a truly polar region, for during the long winter period the sea areas are frozen over, and the whole region is the equivalent of a snow covered land surface with a continental climate. The winters, therefore, are extremely cold with the minimum temperature running as low as −56° F. The average precipitation is light but is a little higher than that in the interior region. During the months of July, August, September, and October there is considerable fog and cloudiness and flying conditions are at their worst.

## CANADA

Polar Canada includes the Canadian Arctic Archipelago and most of the north coast of Canada. It is commonly divided into a western portion and an eastern portion. The boundary between the two is rather indefinite, but it is generally regarded as lying along the axis of Boothia Peninsula and Somerset Island. The basis of distinction between the western and eastern parts is twofold; first, the areas themselves differ topographically, and secondly, they

are usually approached from different directions and because of the extensive areas of tundra, rivers, lakes, and ponds that interfere, there is almost no travel between them.

Western polar Canada comprises the mainland from Demarcation Point to Boothia Peninsula, and the islands to the north. The largest of these is Victoria Island, the second largest in the Archipelago and about the size of Oregon. Most of western polar Canada is low lying. There are few mountains, and, as a result, there are few glaciers. In some localities, however, there are perennial snowbanks. The mainland is rocky in many places, except around the mouth of the Mackenzie River. The islands are also rocky but much of the rock is concealed beneath tundra vegetation, mud, and sand.

Eastern polar Canada comprises most of the mainland coast from Boothia Peninsula to Labrador, and the islands to the north. Of these, Baffin Island, almost as large as Texas, is the largest island in polar Canada. In contrast with western polar Canada, eastern polar Canada is generally high and in places very rugged. The east coast of Baffin Island and the eastern and northern parts of Ellesmere Island have mountains, the maximum altitudes of which approximate 8,000 feet on Baffin Island and 11,000 feet on Ellesmere Island. Both islands have numerous valley glaciers in their mountainous parts, and both have small ice caps in addition. Glaciers are also present on Bylot Island, Devon Island, and Axel Heiberg Island. Well-developed fjords penetrate the coasts of most of these islands, especially Baffin Island and Ellesmere Island. Bare rock surfaces are more common in Canada's eastern polar region, particularly in the mountainous areas, than in the west; yet low, tundra-covered regions also occur. On the mainland, for instance, the entire west cost of Hudson Bay is low and flat and, in most places, characterized by tundra.

Most of Canada, down to and across the United States border, was heavily glaciated during the ice age. This has resulted in blocked drainage, drifts, boulders, and scoured rocks which give the Canadian landscape characteristics that make it appear quite unlike that of Alaska.

A very large part of the Canadian mainland is sub-polar. Even the north coast is, in a few places, sub-polar rather than polar. The principal natural regions are the western mountains and the interior lowland, which comprise the Mackenzie River valley and the broad expanse of generally flat country that characterizes the rest of the sub-polar mainland. The little known Mackenzie Mountains and some other ranges of northwestern Canada, together described as the western mountains, represent the northward continuation of the Rocky Mountains of the United States and southern Canada. Altitudes of 7,000 to 8,000 feet are common, and some of the peaks carry snow the year around.

The Mackenzie River, like the Yukon, is one of the great rivers of the world. From early July to mid-September it is navigable for steamboats from the Arctic Ocean to Fort Smith on the Slave River south of Great Slave Lake, a distance of 1,300 miles. In many places the Mackenzie valley is well forested and fertile. Gigantic Great Bear Lake, noted for its radium ore, is separated from the Mackenzie Valley proper by a short and low range of mountains. Other smaller lakes are scattered throughout the region of Mackenzie Valley.

East of the Mackenzie Valley lies a broad, comparatively flat plain, the surface of which has a maximum altitude of about 1,400 feet and slopes gently downward to sea level around Hudson Bay. The northeastern part is treeless and truly polar. The sub-polar remainder is forested and forms a broad basin around James Bay, the southern extension of Hudson Bay. Most of this part of the interior lowland is underlain by rocks. Countless lakes constitute another notable feature of the region.

## GREENLAND

Greenland is not only the largest of the north polar lands, but also the largest island in the world. More than three-fourths of it is occupied by an ice cap that covers all of the interior and leaves only a relatively narrow ice-free strip along most of the coast. Next to the Antarctic ice cap, the Greenland ice cap is the largest in the world. It is roughly dome-shaped, reaches a maximum altitude of about 10,000 feet, and is constantly but very slowly flowing outward. Not much is known concerning its thickness except that in some places it is probably 6,000 to 7,000 feet thick. Near the margin of the ice cap there are numerous crevassed areas. These make travel very dangerous and in some localities almost impossible. Crevasses have been reported in a few places in the interior also.

Many valley glaciers extend outward from the ice cap to the coast. They are the outlets through which the slow-flowing ice is discharged from the ice cap into the sea in the form of large icebergs. Most of the Greenland coast extends out beyond the ice cap, although there are a few stretches, especially in northwest and northeast Greenland, where the ice cap descends directly to the sea. Much of the coastal zone is mountainous, with individual peaks called "nunataks" projecting through the margin of the ice cap.

Fjords cut deeply into the Greenland coast. Many of them are magnificent. The East Greenland fjord system is one of the most imposing in the world. Scoresby Sound, which extends inland more than 150 miles, is the longest fjord in the world, and Franz Joseph Fjord with its precipitous vari-colored walls equals the splendor of the Grand Canyon. Most fjords have glaciers at their heads, and unless you know the fjord thoroughly, don't fly into it. You may not have room enough to turn about. Even if the slope of the glacier is gradual, it may cause you trouble, for it may cause you to fly into a nunatak lost in the fog.

One of the most amazing parts of Greenland is Pearyland, the northern portion of Greenland and the most northerly land in the world. Pearyland is virtually ice and snow free in summer, and there is no evidence that even in the past ice age ice ever covered the portion north of Hyde Fjord. In fact, remains of old Eskimo habitations have been found in Pearyland within 6° or 7° of latitude from the North Pole. The snowfall in winter is light and melts early in the spring. This, together with the absence of lakes and streams, gives the country an almost desert-like appearance. Nevertheless, the tundra abounds in bird and animal life, including musk ox.

## LABRADOR

Although Labrador lies entirely south of the Arctic Circle, its northeastern part is truly polar. This part of Labrador, like much of Canada's eastern polar region, is mountainous, particularly in the north where the Torngat Mountains reach a maximum altitude of just over 5,000 feet. Fjords penetrate the coast in many places. In the southern half of Labrador there are only a few fjords, but one, Hamilton Inlet, is several times as large as any other in the country. No trees grow in the northernmost part, but the southern part is forested. The southern portion is also less mountainous, and gradually merges with the sub-polar interior lowland of Canada.

## NEWFOUNDLAND

The island of Newfoundland has a very irregular shoreline similar to that of Labrador. However, the coast itself is generally much less abrupt, and the island as a whole is low-lying in comparison with Labrador. The most marked topographical feature, aside from the irregular fjord-like shoreline, is the Long Mountain Range, which extends northeast-southwest along the west coast and reaches altitudes of 2,000 to 3,000 feet.

## OTHER COUNTRIES

This guide deals only with the North American polar regions. Hence Iceland and the polar portions of Europe and Asia are not discussed here. However, most of the information given will apply to these lands as well.

CHAPTER 3

# WATER AREAS

## NORTHERN SEAS

The principal northern seas of the Western hemisphere are the Arctic Ocean, Greenland Sea, Bering Sea, Baffin Bay, and Hudson Bay. The first three also are common to the Eastern Hemisphere. Each of these seas occupies a distinct basin or otherwise easily delimited region. Each is essentially polar.

The Arctic Ocean (area, approximately four and one-half million square miles), is by far the largest of the northern seas. Parts of it are given local names such as the Beaufort Sea (on the north coast of Alaska) and the East Siberian Sea (north of Siberia). The Arctic Ocean fills the Arctic basin, which in turn occupies the central part of the polar region. In this respect the Arctic differs markedly from the Antarctic, the Antarctic being a high continent rather than a basin. Surrounding the Arctic basin is a shallow continental shelf over which the ocean extends. This shelf lies at a depth of several hundred feet and is of varying width. Most of the Canadian polar islands lie on this shelf. From its edge, an abrupt slope leads down to depths of several thousand feet. The greatest known depth of the Arctic Ocean is nearly 18,000 feet.

North of Iceland and between east Greenland and Spitzbergen lies the Greenland Sea.

Although its surface waters have a broad connection with the Arctic Ocean, it occupies a distinct basin. For this reason, it is regarded as a separate body of water. Its maximum depth is almost 16,000 feet.

The Bering Sea lies north of the Aleutian Islands and separates Alaska from Siberia. It is divided into two parts, a southwestern basin with depths as great as 13,000 feet, and a northeastern shelf with an average depth of only about 330 feet. The Bering Sea connects with the Arctic Ocean through the Bering Strait, which is both narrow (57 miles wide) and shallow (not much more than 150 feet at the narrowest part). Within the Bering Strait are the tiny Diomede Islands, where the American and Russian territories are in greatest proximity. Little Diomede, owned by the United States, is less than 3 miles away from Big Diomede, owned by Russia.

Baffin Bay separates Baffin Island on the west from Greenland on the east. It has an independent basin more than 6,000 feet deep. On the north and west, Baffin Bay connects with the Arctic Ocean through various channels of the Canadian Arctic Archipelago, and on the south, it joins the Atlantic Ocean through Davis Strait.

Hudson Bay is strictly a shallow inland sea. It reaches the North Atlantic Ocean through Hudson Strait, a lane 500 miles long that separates Baffin Island from Labrador. Foxe Basin, a northern continuation of Hudson Bay, connects through the narrow Fury and Hecla Strait, with the channels of the Canadian Arctic Archipelago. Depths in Hudson Bay are generally less than 650 feet. The bottom is gently shelving so that the water is shallow for some distance off shore. As a result, retreating tides uncover extensive mud flats.

## ICE

An outstanding characteristic of the northern waters is the vast amount of ice in these waters. Most of this is *sea ice*—that is, ice formed by the freezing of sea water. Depending on the rate of freezing, this type of ice is more or less salty to begin with. However, as it ages, melting and refreezing, the salt gradually sinks to the bottom and the ice loses its salt content.

Sea ice takes many forms and is known under a great variety of names, depending on its condition. While these names are not yet completely standardized, the latest authoritative definitions in use by the United States are given in the *Glossary of Ice Terms* at the end of this chapter.

In general, *fast ice* is sea ice attached to and extending from the coast. *Drift ice* is the sea ice which moves under the influence of winds, currents, and tide. It may be fast ice that has broken off during the summer, or it may be ice formed over the sea. A *floe* is a cake of drift ice, and a *lead* is a channel of unfrozen water between floes.

As the floes move around because of the action of winds, currents, and tides, they may come together with considerable force, with their edges breaking off or one edge passing over the other. This process is called *rafting*. The pressure on the floes often causes *hummocks*, or *pressure ridges*, irregular elevations on the floes.

Except in mid-summer, about 80% of the ice floes are smooth enough for a wheels-up landing. Wheels-down landings, however, are dangerous because you can't notice hummocks or small drifts on the floes and may readily nose over.

*Icebergs* are blocks of fresh-water ice that have broken off from the great terminal cliffs of glaciers which end in tidewater. These blocks are under greater influence from the currents than is the ice pack and float further south than any other type of ice. Since icebergs are generally much thicker than floes of sea ice, they sink to a much greater depth (they are 5/10 to 9/10 below water) and also rise much higher in the water. While they are a magnificent sight, keep away from them if you are in a boat. They frequently roll sideways or turn upside down without warning and create waves that can easily swamp a boat. Because they are derived from large glaciers, imposing icebergs are more common in the large glacier occupied fjords of Greenland than in any other place in the Northern hemisphere.

## POLAR ICE PACK

The polar ice pack—it is *not* an ice *cap* for it is not over land—covers the North Pole and the whole central polar area. The average thickness of the pack ice is about 9 to 12 feet in winter and 7 to 9 feet in summer. However, it is not a solid field of ice, for even in midwinter currents and winds cause the ice to crack apart and develop lanes of open water. In summer, according to the observations of the 375th Weather Reconnaissance pilots flying over this area, there are four definite zones of the pack:

(1) From Pt. Barrow to 75° North, there is an area of open water 50 to 75 miles wide north of the mainland with the ice beyond that point extremely rough and composed of relatively small broken ice floes increasing in size toward the north.

(2) From 75° to 80° North, the floes increase in size but still present a broken rough appearance.

(3) From 80° to 85° North, the ice has a smooth unbroken appearance, and radar observers experience great difficulty in locating landmarks for their wind runs. What leads there are appear longer and thinner than at other latitudes.

(4) From 85° to 90° North, the ice becomes rougher and a bit more broken in appearance. The floes here are apparently smaller but more closely packed than those between 75° and 85° North. Radar targets in this area are still discerned with difficulty but are definitely more numerous than those between 80° and 85° North.

It is interesting to note that most of the observers felt that from the appearance of the sea ice they could define their latitudes within 300 miles.

No matter how extensive, the pack ice always moves under the influence of currents and winds. Sometimes, instead of being pulled apart, the fields and floes along the edges of the pack are shoved together with terrific force. To those who have witnessed it, the slow grinding and crushing of floes being pushed and piled up over one another is an experience never to be forgotten. This telescoping and piling up of floes results in thicknesses sometimes as great as 30 feet.

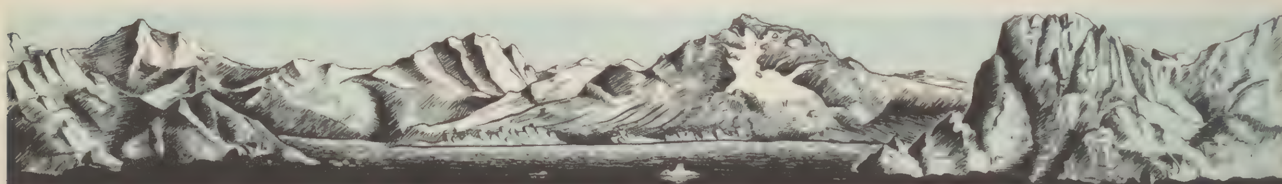
During the summer (June, July, and August), any lanes that are formed remain ice free. On the surface, an average of 3 feet of ice melts from the floes, and they are covered with pools of water.

### TIDES

The tides in the polar areas vary widely from place to place. Tide ranges are always smaller along straight parts of a coast than at the heads of funnel-shaped bays along the same coast. Frobisher Bay, in the southeastern part of Baffin Island, has a funnel shape and its tide range is twenty to thirty-five feet. Yet at Clyde Inlet, on an open stretch of the northeast coast of the same island, the tide range is only two to three feet. In most parts of the polar region, small tides are more common than those of greater range. Winds are an important influence. On the north coast of Alaska and Canada and in Greenland, winds sometimes raise or lower the normal tide by two to three feet, depending upon the direction from which they are blowing. In the American and Canadian sectors of the Arctic Ocean tidal ranges are generally slight. Thus along most of the north coast of Alaska, the tide is less than one and a half feet. Tides are small also in the channels leading from the Arctic Ocean into the Canadian Arctic Archipelago.

### CURRENTS

The climate of various parts of the polar regions is strongly influenced by currents in the sea. An example is the cold current flowing from the north past the coast of Labrador. It keeps the Labrador coast cold in comparison with other coastal areas in the same latitude. In the North Pacific, the warm Aleutian Current and its northern branch, the Alaska Current, give relatively warm winters to the Aleutian chain and the south coast of Alaska. Currents also influence the navigability of certain waters by controlling the direction of movement of sea ice. Currents have been responsible also for the driftwood along some polar shores—driftwood that has saved many lives in the past and will likely save more in the future.



# GLOSSARY OF ICE TERMS

**Ablation**—Surface waste of snow or ice due to melting or evaporation.

**Anchor ice**—Some use this term for all submerged ice attached to the bottom, regardless of its mode of formation. Others feel the term should be limited to river ice. (See Bottom ice.)

**Arctic pack**—(See Pack ice.)

**Avalanche**—A mass of snow or ice detached from its position, and slipping down a slope.

**Bay ice**—This term should no longer be used, for different authors have used it as a synonym of young ice, fast ice, level ice, as well as for any ice formed in a bay.

**Belt**—A strip of cakes, floes or fields of ice of such extent that its lengthwise limits cannot be seen from the crow's nest.

**Bending**—The first stages of pressure, characteristic of thin and very plastic ice.

**Berg**—(See Iceberg.)

**Bergy bit**—A large piece of glacier ice rising 8 to 16 feet above the surface of the sea (erroneously used by some authors for a small growler).

**Beset**—When a vessel is so closely surrounded by sea ice that control of its movements is lost, it is said to be beset. (See Nipping.)

**Bit**—A single piece of ice less than 2 feet in diameter. (Compare with Glacon and Brash ice.)

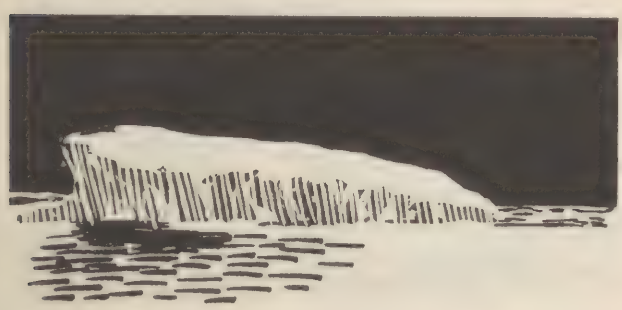
**Black ice**—Thin dark-appearing ice, with no snow covering. (Compare with Ice rind.)

**Blink**—(See Ice blink, Water sky, Sky map.)

**Blizzard**—Snow drifting so high and thick that it is difficult or impossible to tell whether the sky is clear or clouded. (See Snow storm, Drift.)

**Block**—Small piece of ice. (See Cake.)

**Blocky iceberg**—An iceberg having a nearly horizontal surface and steep sides.



*Blocky Iceberg.*

**Boring**—Forcing a vessel steadily through ice under power of engine or sail so as to progress by pushing adjacent floes apart. Also called slewing. (See Bucking, Ramming.)

**Bottom ice**—Depth ice that has reached and clung to the bottom. (See Anchor ice, Depth ice.)

**Brash**—Small floating ice fragments, often rounded; the wreck of other masses of ice; Sometimes called slob ice.

**Broken belt**—The outer fringe of polar ice, consisting of scattered floes and cakes. It may be many miles broad.

**Broken ice**—Ice consisting of scattered cakes and floes.

**Bucking**—Term was used, especially by Yankee (New Bedford) whalers, to describe charging ice with a ship under full power, then backing up and charging again. (See Boring, Ramming.)

**Cake**—A relatively flat piece of ice, smaller than a floe. (Compare with glacon.)

**Calved ice**—A low-lying piece of glacier ice, less than 16 feet above the surface of the sea; a small piece is called a growler, a large piece, a bergy bit.

**Calving**—The breaking away of a mass of ice from a parent berg, glacier, or barrier.

**Candle ice**—Long crystals formed in fresh water ice, or in salt ice that has become fresh. These are vertical (at right angles to the surface of the water) and the length of each is the same as the thickness of the ice. Their tips are sharp and will cut shoe leather and the pads of dogs' feet. Also called needle ice.

**Channel**—(See Lead.)

**Clearing**—A roundish opening in the ice with a maximum width of a few hundred yards. A larger opening may be called a big clearing. (Compare with polynia.)

**Close ice**—Ice so closely packed that it covers 7/10 to 9/10 of the sea surface, making navigation difficult or impossible.

**Close pack**—(See Close ice.)

**Coast ice**—(See Fast ice.)

**Collar ice**—(See Ice foot.)

**Compact ice**—Continuous, although broken, ice with few indications of open water to be seen from some vantage point, such as the masthead.

**Concrete**—(See Snow concrete.)

**Confluent ice**—Ice sheets formed by the coalescence of ice tongues from several glaciers, held together by a land barrier along the seaward edge.

**Conglomerated pack**—High hummocky floes interspersed with icebergs. Not navigable.

**Consolidated pack**—Field ice, or the heaviest form of pack, containing much pressure ice, and entirely devoid of water spaces.

**Cornice**—Snow or ice overhanging the lee edge of vertical ice cliffs.

**Crack**—A narrow fissure in sea or lake ice; usually results from the action of winds or currents, or from temperature changes. Ordinarily sledge travelers speak of a crack if a man can jump over it but of a lead if he cannot jump across. Sailors sometimes use crack to denote a lead too narrow for a ship's passage.

**Cream ice**—(See Ice cream.)

**Crevasse**—A fissure or rift in glaciers, shelf ice, or other land-ice formations, due to thermal changes in the ice or to motion of the ice over underlying obstacles. Appearance of crevasses depends on whether produced by shear or tension.

**Crow's nest**—A basket or cage, near or at the head of the mast, from which the ice pilot or other officer scans his surroundings. On the Yankee and other Arctic whaling ships the height above the sea would usually be from 70 to 100 feet.

**Debacle**—The break-up of ice in rivers in the spring. (See Ice jam.)

**Debris ice**—(See Muddy ice.)

**Depth ice**—Small particles of ice formed below the surface of the sea when it is both sufficiently chilled and sufficiently churned up by wave action.

**Disburbed ice**—Any land ice which is broken by pressure into a chaotic pattern of elevations and depressions.

**Drift**—Wind-driven snow in motion along the surface sometimes rising to heights of 100 feet or more; snow lodged in the lee of surface irregularities under the influence of the wind. The motion of sea ice or vessels resulting from ocean currents. (See Snowstorm, Blizzard.)

**Drift ice**—Very open pack, where water predominates over ice. The floes are usually smaller than in close or open pack with much rotten ice and brash, and vessels usually can pass through it without altering course or speed. Known also as sailing ice.

**Fast ice**—Stretches of unbroken ice attached on one side to the shore (in bays, fjords, and among islands or stranded hummocks). The 12-fathom isobath is often near the maximum limit of the spread of fast ice. It usually breaks up during the summer.

**Fat, ice fat**—Tiny ice crystals which make the sea look as if watered silk had been spread over it.

**Field**—The largest connected areas of drift ice. They are from several to scores of miles wide; their limits cannot be seen from a ship's masthead.

**Firn**—(See Neve.)

**Flaw**—Term used by Yankee shore whalers, as at Point Barrow, in two senses: (1) the outer edge of the landfast ice; (2) the shore lead, just outside the fast ice, along which whales migrate (especially on the northwest coast of Alaska, between Point Hope and Point Barrow).

**Floe**—An area of drift ice from a few hundred feet in diameter to the size of an ice field.

**Floe belt**—The area inside the broken belt.

**Floeberg**—A detached massive hummock which is formed by the piling up of the heaviest ice due to great pressure; it may rise 60 feet above the surface of the sea—especially in the Beaufort Sea where Yankee whalers have reported ice even with the crow's nest, that is, 70 to 100 feet above the sea.

*Drift Ice.*

**Flower ice, ice flowers**—The crush of salt crystals on top of ice that is forming at sea, especially when freezing is rapid.

**Fossil ice**—(See Ground ice.)

**Frazil**—Fine spicular crystals and ice plates encountered in water which is disturbed or turbulent and which do not form a sheet.

**Fresh ice**—Has been employed to describe newly formed ice of different types (compare with Young ice). This term should not be used because it conflicts with other definitions of fresh ice, among them (1) ice that has always been fresh (salt-free) and (2) ice that was salty but is now fresh.

**Frost smoke**—The fog-like clouds that form over water areas or over young ice.

**Giant floe**—(See Field.)

**Glacon**—A piece of sea ice smaller than a floe, an ice cake. (Compare with Bit, Growler, and Bergy bit).

**Glacier**—Any field or stream of ice of land origin. It may be either active or stagnant. The principal forms of glaciers are continental and various types of mountain (valley) glaciers.

**Glacier ice**—Ice which originates from glaciers.

**Glacier tongue**—Extensions of outlet glaciers into the sea. Their fronts are rather generally afloat.

**Glass ice**—A thin sparkling crust on a calm sea produced by the coalescence of patches of ice fat.

**Grease**—(See Ice fat; also Slush.)

**Ground ice**—Chunks, lenses, or layers of ice found in frozen ground.

**Grounded ice**—Ice that is so heavily aground that it does not move before a wind or current.

**Growler**—A small piece of glacier ice, rising 2 to 7 feet above the surface of the sea (used by some authors for pieces of hummocky drift ice, by others for both drift ice and glacier ice.) (Compare with Glacon.)

**Gulf ice**—(See Bay ice.)

**Haycock**—Isolated ice blocks in the form of a haycock, thrown up above the surface of land ice or shelf ice, resulting from pressure or ice movement. Radiating crevasses are always present.

**Heavy ice**—Any sea ice more than 3 or 4 feet in thickness.

**Hinge crack**—A longitudinal crack formed in front of a pressure ridge because of its weight.

**Hole**—An opening through the ice (compare with Rotten ice); an open space in an area where floes are otherwise closely packed together.

**Hummock**—An elevated ice ridge on sea ice, due to ice pressure. If melting or weathering has occurred, hummocks assume a rounded shape called moutonee.

**Hummocking**—Process by which the young and level sea ice becomes built up into hummocky ridges. The terms bending, tenting, and rafting, describe different phases of the process.

**Hummocky floes or fields**—Areas of hummocked ice frozen together.

**Iceberg**—A mass of floating or stranded glacier ice rising more than 16 feet above the surface of the sea.

**Ice blink**—The whitish glow or glint on clouds. It is a mirroring in the sky of (usually snow-covered) ice. Some claim blink can also be seen near the horizon, even if there are no clouds. (See Land sky, Water sky.)

**Ice block**—(See Bergy bit.)

**Ice cap**—A flat dome-shaped glacier covering a land area. The term is also applied to continental glaciers or ice sheets.

**Ice cream ice or cream ice**—Young ice, usually less than 3 inches thick, which contains so many cells filled with unfrozen brine that a piece of it splashes or flattens like ice cream if dropped on a hard surface.

**Ice edge**—The outer margin of the ice, bordered by open water.

**Ice fall**—An interruption in the surface of a glacier, caused by an abrupt change in the slope of its bed, resulting in disturbed ice usually in the form of steep or precipitous ice cascades.

**Ice fat**—(See Fat.)

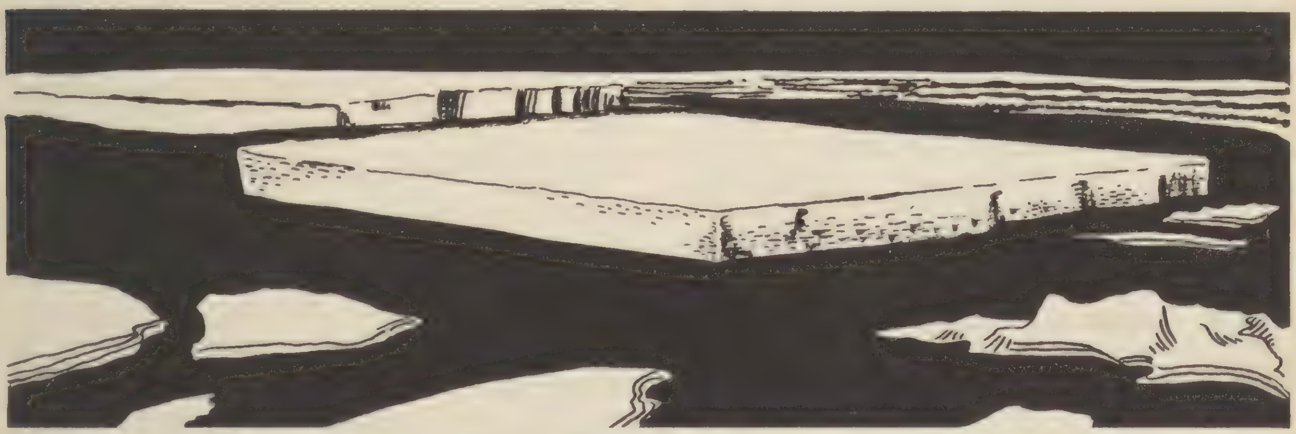
**Ice field**—(See Field.)

**Ice flowers**—(See Flower ice.)

**Ice foot**—A low fringe of fast ice of varying height which skirts the shores. The various types are (1) tidal platform ice foot, (2) storm ice foot, (3) drift ice foot, (4) pressure ice foot, and (5) stranded floe ice foot.

**Ice jam**—The heaping of a broken river ice in spring at a narrow part of the channel, permitting the water to dam up behind the jam, perhaps to flood surrounding lowland.

**Ice limit**—The greatest extent of the ice at any given time.



*Cakes, Glacons, and Growlers.*

**Ice rind**—Hard ice formed by the freezing of slush in calm water at low temperatures.

**Ice sheet**—A large area of continuous ice overlying a land surface.

**Ice sky**—(See Ice blink.)

**Ice tongue**—Glacier ice extending seaward from shore; the source of icebergs. (Compare with Tongue.)

**Inland ice**—(See Ice sheet.)

**Land blink**—(See Land sky.)

**Land floe**—Fast ice which has broken away from the shore (also used as a synonym of fast ice).

**Land ice**—Ice that has formed on land, usually from snow.

**Land sky**—The mirroring of land in clouds. If the land is fully snow covered its cloud appearance is identical with that produced by fully snow-covered ice (compare with Ice blink). If some dead grass sticks out through the snow the land sky is yellowish; if the land is snow-free its sky reflection is nearly black, though seldom the uniform black of water sky. (See Sky map.)

**Landfast ice**—Same as Fast ice.

**Lane**—Same as lead.

**Lead**—Thought of by sailors as a navigable passage through any kind of ice. Sledge travelers think of a lead as an ice crack too wide for men, sledges and dogs to cross easily—that is, any crack wider than 3 to 5 feet.

**Level ice**—Ice of uniform thickness, with a flat and smooth surface; it is more than 8 to 10 inches thick (if thinner it is called young ice).

**Light ice**—Winter ice up to 2 feet in thickness.

**Loose ice**—(See Open ice.)

**Marginal crushing**—The process which occurs when floes collide with pressure.

**Moutonnee**—A term sometimes used to describe the weathered appearance of hummocky polar ice after the sharp forms of the hummocks and pressure ridges become rounded through melting (that is, Paleocrystic ice).

**Muddy ice**—Ice which contains mud, stones, shells, etc.

**Needle ice**—(See Candle ice.)

**Neve**—Compacted snow, hardened by wind and thermal variations, in transition from soft snow to glacier ice. It contains much air, and is found in the upper regions of glaciers.

**Nipping**—Closing up of the ice so as to pinch a vessel. It differs from beset in that for nipping you think of two pieces of ice closing like a vise while beset pictures a ship hemmed in by several pieces of ice and thus prevented from moving.

**Nunatak**—An island of bare earth standing above the surrounding sheet of land ice.

**Old ice**—(See Paleocrystic ice.)

**Open ice**—Scattered ice covers from 5/10 to 8/10 of the sea surface; navigation is possible.

**Open lead**—A lead that has not been frozen over yet.

**Open pack**—(See Open ice.)

**Open water**—Water free of drifting ice, or thought of as reasonably free.

**Pack ice**—Sea ice which has drifted from its original position. It is classified according to arrangement and size of the floes into (1) field ice, (2) close pack, (3) open pack, and (4) drift ice.

**Pack, the**—This term is used in a wide sense to include all types of sea ice other than Fast ice.

**Paleocrystic ice**—Very old hummocked ice which may be up to 160 feet in thickness. The pressure heaps and ridges have been so much rounded by sun and rain that a snow-covered paleocrystic field is reminiscent of a rolling prairie in winter.

**Pancake ice**—Small cakes of new ice approximately circular; usually having raised rims. They are 1 to 3 feet in diameter and 4 inches or less in thickness.

**Patch**—An irregular small gathering of drift ice.

**Plate ice**—(See Pancake ice.)

**Polar cap ice**—This term is derived historically from the mistaken assumption that there is around the Pole a cap of unbroken ice. The expression should not be used; for at best it is overlapping and thus confusing.

**Polar ice**—Ice which is more than one year old and which is thought of as having drifted down from higher latitudes.

**Polynia**—Any enclosed area of water (other than a crack or lead) among fields and floes of pack ice.

**Pool**—A depression in fields or floes containing water. Some authors limit the term to depressions containing fresh water; others use it as a synonym for polynia.

**Pressure ice**—Ice fragments in heaps; sometimes ridges, produced by crushing.

**Pressure ridge**—Pressure heaps arranged in a long ridge.

**Pyramidy icebergs**—All icebergs that are not blocky; the form varies widely.

**Rafted ice**—Ice, consisting of several layers, formed by relatively thin pieces of ice being pushed upon or beneath other pieces under pressure.

**Rafting**—Overriding of one floe on another as a result of pressure.

**Ram**—A snag jutting out below the water line from a floe or berg, produced either by the melting of the ice due to an increase in the temperature of the surface water or by the original projection of a lower component of rafted ice.

**Ramming**—Charging ice with a ship under full power ahead. If this is repeated it becomes bucking.

**Regional clearing**—(See Polynia.)

**River ice**—Ice formed in rivers; even in spring it represents a very small part of the floating ice in the sea and disappears in early summer.

**Rotten ice**—Ice which has become honeycombed (full of holes) during melting and, therefore, lacks the strength of other ice. May also apply to ice which disintegrates easily because it has become (or always was) fresh and is candling. (See Candle ice.)

**Rough ice**—Fast ice, floe or field, that has been made uneven by ridges and piles of Pressure ice, which see.

**Rubber ice**—(See Sludge ice.)

**Sailing ice**—(See Open ice.)

**Sastrugi**—Snow drifts, used especially for drifts that are long and hard because the wind that made them was strong. The implication usually is, too, that their lee ends are fairly high, with an abrupt drop if not an overhang.

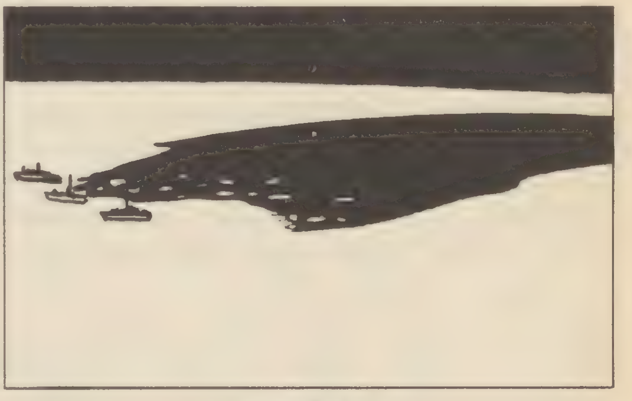
**Scattered ice**—The sea is from 1/10 to 5/10 covered with ice cakes and floes. (Compare with Open ice.)

**Screw ice**—(See Pressure ice.)

**Screwing pack**—Floe in rotary motion due to the influence of wind and pressure. This type of pack is most dangerous to vessels.

**Shear cracks**—Cracks in glaciers or sea ice caused by differential movement. The sheared parts undergo a displacement parallel to the plane of the crack.

**Sheet ice**—(See Ice rind.)



*Ross Shelf Ice.*

**Shelf ice**—An extensive glacial ice sheet which, although originating on land, continues out to sea in the form of a shelf beyond the depths at which it rests on the sea bottom. Most widely known example is that in the Ross Sea in the Antarctic.

**Shore clearing**—Space of open water formed near the shore during the melting of the ice. (Compare with Shore lead.)

**Shore ice**—Used by some authors as a synonym of fast ice.

**Shore lead**—A lead between the drift ice and the shore, or the drift ice and a narrow belt of fast ice, or the fast ice and the shore. The first two types may develop in any season, usually with offshore winds, but the third type occurs only in summer when the fast ice on the inside of stranded ice melts.

**Sikussak**—Very old ice, which does not drift, located in fjords on the north coat of Greenland. Resembles glacier ice, since it is formed to a great extent by snowfall and snowdrifts.

**Sklyanka**—(See Glass ice.)

**Sky Map**—The mirroring of land, water, snow, glare ice, etc., in the clouds. A sky map approaches perfection as the clouds on an overcast day approach uniformity.

**Slack ice**—(See Open ice.)

**Slob**—(See Snow sludge.)

**Slob ice**—Sludge or sludge ice pressed together, forming a compact layer through which small vessels cannot pass.

**Sludge**—Accumulations of small pieces of soft ice mixed with slush and sludge ice (used by some authors as a synonym of brash ice).

**Sludge ice**—All kinds of soft ice, the pieces of which are not strong enough to bear the weight of a dog or seal.

**Sludge lumps**—Small irregular lumps formed by the freezing of slush during strong winds.

**Slush**—Accumulation of ice crystals which are either not frozen together or only slightly frozen together; appears grey or lead-tinted. Wind ripples disappear when slush is present.

**Snezhura**—(See Snow ice.)

**Snow concrete**—Snow which has been compressed at a low temperature and which has then had sufficient time to harden. This formation is strikingly noticed when the tread of an animal has compressed new-fallen dry snow and when a blizzard has come along several hours later. The wind then sweeps away the rest of the snow, leaving the tracks of the animals standing up, each on its own pillar of snow concrete. The track of a sledge, under similar conditions will be revealed as parallel lines that are reminiscent of rails on a railway track.

**Snow ice**—Young ice, the first crust of which has been formed in considerable part from falling or drifting snow.

**Snow drift**—Snow piled by the wind into a ridge that has a long axis parallel to the wind. (See Sastrugi.)

**Snow sky**—Reflection of snow covered ice or land in the sky, used especially of the whitest patches in the sky which show that snow is more uniform below them than below the darker patches which represent glare ice or partly snow-free land. (See Sky map.)

**Snow sludge**—Sludge formed from snow.

**Snow storm**—A combination of falling and drifting snow. (See Drifting, Blizzard.)

**Spring sludge**—(See Rotten ice.)

**Stagnant glaciers**—Glaciers which have ceased to move.

**Storis**—The word, literally, means "big ice," but actually it is used to describe relatively small fragments into which heavy ice of the Arctic basin has been broken in its passage south, chiefly through the strait between Greenland and Spitsbergen but also through the narrower gap between the Spitsbergen and Franz Josef island groups.

**Stranded ice**—Heavy sea or glacier ice which has been stranded in shallow water. (See Grounded ice.)

**Streams**—Long narrow areas of drift ice; usually consist of small fragments detached from the main belt, and drift under influence of wind or current.

**Strip**—(See Streams.)

**Telescoped ice**—(See Rafted ice.)

**Tenting**—The process of pressure causing the piling up of heavy floes into pressure ridges.

**Tide crack**—Crack, usually parallel to a shore, caused by the movement of the tides; one or more may occur if there is a pronounced rise and fall. (On most Arctic coasts the tide is of inches or feet, seldom of meters or fathoms.)

**Tongue**—A projection of the ice edge which may be several miles long, caused by winds and currents.

**Water sky**—Dark patches or streaks on the clouds due to the reflection of leads and polynias, or a uniform black due to an open sea in the vicinity of large areas or ice or snow-covered land. Details of the arrangements of the ice can be seen clearly when low stratus clouds are present. (See Sky map.)

**Winter ice**—Ice frozen during the last autumn, winter, or spring and therefore not more than one year old.

**Young ice**—Newly frozen stretches of ice, 2 to 8 inches in thickness; the appearance depends upon the process of formation. It is usually formed from pancake ice. It is dark in color, moist on top, and is neither hard nor tough. (A slab of 3-inch fresh water ice, if dropped on a rock, will splinter like glass; a chunk of 3-inch salt water ice would splash like ice cream. See cream ice, ice cream ice.)

CHAPTER 4

# LIVING

## PLANTS

No matter how far north, any land that is free from snow and ice even a few weeks in the year has plants growing on it. The world's northernmost land, the north tip of Greenland, supports many kinds of plants in such abundance that several herds of musk oxen find adequate pasture there. If you have seen an alpine meadow above the timberline on a high mountain, you can picture in a general way the vegetation of the polar region—the polar tundra. The tundra gives way southward, through a broad transition belt, to the sub-polar forest, or *taiga*, which in turn merges into the more familiar trees of the temperate zone.

Northward from the boundary between the United States and Canada, the light green of hardwood forests and the variegated patchwork of fields and pastures are succeeded by an expanse of dark evergreen forest, broken only by lighter patches of bog (muskeg) and numerous lakes. At first, the forest is a variable mixture of many kinds of trees. Farther north, one kind after another disappear until eventually the landscape beomes a vast monotonous stretch of sub-polar forest (*taiga*), reaching across southern Canada and central Alaska to within a short distance of the Bering Sea. Black and white spruce predominate. Interspersed among the spruces are the eastern larch (tamarack), aspen, balsam poplar (balm of gilead), and paper birch. The trees grow close together and are often draped with gray lichens. Soft spongy moss and lichens cover the ground almost entirely. Scattered through this dense forest are innumerable lakes and bogs. Because of the growth of grasses, sedges, and peat moss (sphagnum) about their margins, many of the lakes are gradually becoming bogs. The plants form a mat which floats on the water and quakes when walked upon. As this mat gets thicker, cranberry, Labrador tea, leather leaf, and other shrubs

appear. These are followed by alder, black spruce, and larch. Many lakes have been completely filled in and are now covered by dense forest. Summer travel on foot is difficult. Trees grow so close that it is difficult to press through them. You tire quickly as you sink into the soft ground-cover at every step. This land can be treacherous, too, for it is easy to fall into half-concealed holes in bogs and bog forests.

The transitional belt of vegetation between the sub-polar and the polar regions consists of a patchwork of forest and tundra. Tundra first appears in small clearings in the forest. Northward the patches of tundra increase in size and abundance until they equal the forest in extent. Still farther north, the trees disappear entirely as the transition to polar tundra is completed. Thus the northern edge of the sub-polar forest is not a definite line. From the main mass of the forest, slender strips of trees reach north along the river valleys where the soil and moisture are favorable. Isolated clumps of trees form outposts far north of the main mass of the forest. Thus, on the Coppermine River, remnants of the forest extend to within six miles of the Arctic Ocean, while the surrounding rocky upland is gray tundra. As the tree limit is approached, the size of the trees usually decreases; however, there are frequent exceptions. In protected places where the soil is good, white spruce trees are as tall as those a thousand miles farther south. White spruce and balsam poplar are the northernmost trees of the forest.

Lichens, grasses, and sedges (grasslike plants) and several types of shrubs are the predominant plants in the polar tundra. In spite of the wide geographical extent of the tundra, its composition varies little from one area to another. There are no thorny or climbing plants in the polar tundra. Most of the plants branch freely at ground level and many form dense cushions or rosettes. In the winter landscape of the polar region, plants are inconspicuous. Although the snowfall is meager, it is sufficient to form a thin cover over most of the low-growing plants. In wind-swept areas, the snowy expanse is often broken by the tops of projecting plants and grasses. Large areas of the polar tundra consist of heath, a plant community in which low shrubs predominate. Lichens and mosses are also abundant. For a short time during early spring and summer, red, white, blue, yellow, and purple flowers brighten the dull green tint of the heath. During the rest of the year, the plants present a dreary aspect. The shallow depressions between the low hills are occupied by extensive meadows that somewhat resemble prairies. Swampy areas abound. A characteristic polar plant, the spectacular "cotton grass", grows in all the swamps as well as along streams and lake shores. On rocky and sandy ridges flowers are rare, and dark colored "rock-tripe" lichens cover the rock surfaces. These and other lichens intensify the sombre hue of the landscape. The tops of most ridges are covered with reindeer lichen, although some

support scattered grasses and a few flat-lying shrubs. The borders of lakes and streams and well-watered slopes generally support a more luxuriant vegetation. Here the abundant, large plants are a refreshing change from the drab communities of the upland. Shrubs stand upright and form dense thickets. In especially well protected places, willows grow as tall as seven feet and have stems six inches thick.

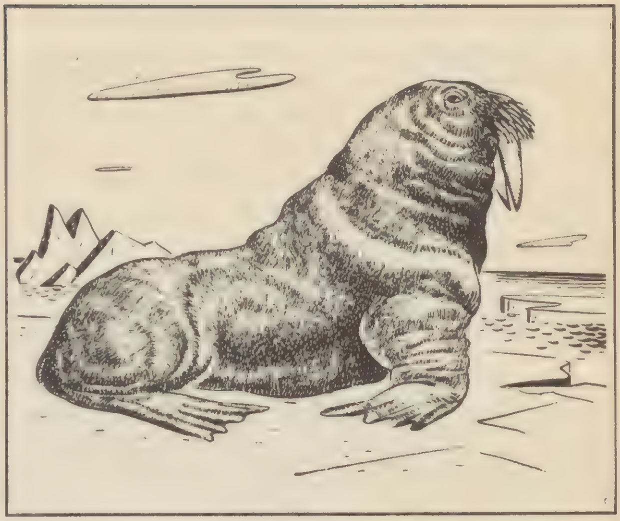
The absence of trees and the general appearance of the vegetation on the Aleutian Islands gives the impression of a polar region. The plants, however, are not those of the polar tundra; they are a special sub-polar group. The westernmost islands support alder and other shrubs tall enough to shelter a rich carpet of flowering plants. In sharp contrast, the eastern islands produce low-growing and less luxuriant plant life. Here and there on the lower slopes of the islands are meadows. Higher up the slopes are willow thickets three to six feet high. Above the willow thickets, the exposed areas are covered with heaths while meadows occupy the hollows. Still higher up, heaths are ever present, giving way in the uppermost regions to large tracts of bare earth.

The southern tip of Greenland lies in the transition zone between the sub-polar and the polar region. It is not surprising, therefore, that bushy willows in a few places grow eight feet tall and have some branches that are six inches thick at the base. These willows branch profusely at the ground instead of having a large central trunk. None of the dominent trees of the sub-polar forest occur in Greenland.

## ANIMALS

Animal life in the polar and sub-polar regions is quite varied. In addition to the polar bears, seals, walruses, reindeer, and whales, generally considered characteristically polar, there are oxen, sheep, rabbits, migratory game birds, fish, and insects.

Polar bears, seals, walruses, wolves, and foxes either live habitually on the pack ice or visit it from time to time. Polar bears belong to the pack ice and are rarely found far from salt water, since they live almost exclusively on seals. Seals are found in various parts of the polar regions. A hair seal known as the "netchek" is particularly common. There are also fur seals and a very large seal often called Stellar's sea lion. Walruses are of two varieties—the Pacific and the Atlantic. The former is larger. It is most common in Bering Strait. The Atlantic species,



*Walrus.*

*Lemming.*

*Grizzly Bear.*

although decreasing, is still found about Greenland, in northern Hudson Bay, and on the Belcher Islands. Walruses are huge, thick-skinned, more or less shapeless creatures that live mostly on clams dredged up on shallow parts of the sea. A big walrus may weigh a ton and a half.

Wolves and foxes are found in many places. The wolves of the Far North are large, extremely wary, swift-footed and strong animals, generally dark in the fall but turning a light gray in the winter. They frequently hunt in groups of 15 or more. While they normally keep away from humans, they sometimes will attack man. They also attack and kill dogs. Foxes are found north of the tree limit and in winter venture out on the pack ice far from land where they feed on seals killed by polar bears. Inland, in the autumn, they dig through the snow for lemmings. Foxes are of varying colors. Some are pure white in winter and in summer have a brownish-gray back and a yellowish throat and belly. The "blue fox" is a blue-gray in winter and dirty gray in summer. Other foxes are red or silver the year around.

Whales inhabit all polar waters. There are several types, including the bowhead whale, the white whale or beluga, the finback or rorqual whale, the narwhal whale, and the "Killer" whale (sea-wolf).

The most important animal of the tundra is the caribou, or reindeer as it is called when domesticated. Because of its uses for food and clothing and its abundance, it is of great value to all inhabitants of the polar regions. It is the one large game animal found throughout the American polar regions, both close to and far from the sea. Moose also inhabit the sub-polar forest and reach the Arctic Ocean, generally only along the Mackenzie Valley. They are rarely found far from water and usually keep to the bush except in midsummer, when they try to escape the flies by getting out into the open. Another animal of the tundra, the musk ox, formerly ranged far down into Canada and Alaska, but now there are no more than 500 left on the mainland, except in one Canadian game refuge. In all the Canadian islands there are probably no more than 13,000 head, with about 9,000 more in northern Greenland. Mountain sheep (bighorns) and mountain goats are also found as far north as the Brooks Range.

Various small animals, including hares, squirrels, and lemmings, live on the hillsides. The Arctic hare, a large rabbit, is smoky gray in summer and white with black ear tips in winter. It is found as far north as there is land and in winter may be met with out on the salt-water ice. The snowshoe rabbit, found in Greenland, is white the year around except for the young, which are a smoky gray until six months of age. Ground squirrels, about the size of gray squirrels but spotted brown in color, also live on the hillsides. Other hillside dwellers are lemmings—plump, short-tailed Arctic mice. They do not hibernate, but they spend most of their time underground or under the snow. Here they build spherical nests of grass where the young are born in spring and throughout the summer. Lemmings are constantly preyed upon by shrews, weasels, foxes, and owls. So dependent are other animals, such as the fox, on the lemming supply, that the abundance of foxes fluctuates with the abundance of lemmings.

The sub-polar forest is the home of three kinds of bears: the Alaskan brown bear (Kodiak), which weighs about 1,500 pounds, and is the largest carnivorous land animal in the world; the grizzly bear which ranges east to Great Slave Lake, Great Bear Lake, and the polar tundra; and the black bear which is more restricted to wooded country but does reach the polar region at the mouth of the Mackenzie River. On the northern fringe of the forests lives the Canadian lynx. The wolverine (large weasel) is usually found in the woods. However, it also ranges out on the tundra. Various smaller animals, such as the snowshoe rabbit, hoary marmot, and porcupine, also live in the forests.

*Gull.*

The polar islands are the nesting places of large numbers of migratory game-birds—such as geese, ducks, terns, gulls and similar shore birds. Inland lakes teem with loons and ducks, while the island cliffs are the homes of many medium-sized, black and white birds. Snowy owls and other birds of prey inhabit the sub-polar forests and the nearby tundra where they live on mice and other rodents. Here live also the ptarmigan—polar grouse which turn pure white in winter except for black tail feathers that show only in flight. In summer their plumage is mottled and barred-brown or black to match their surroundings.

Fish are one of the chief foods in the polar regions. The polar and sub-polar peoples, whether they are Greenland Eskimos, Labrador fishermen, or Alaskan salmon canners, depend for much of their livelihood on fish. Salmon swim up the Alaskan rivers to spawn. Cod are especially numerous off the coasts of Greenland and Labrador in summer. Smaller fish include several kinds of herring, suckers, whitefish, flounders, sculpins, and ling. Fresh water lakes and rivers have fish the year around, salmon, trout, connies, Arctic grayling, and pike.

Insect life in the polar region is less varied than in temperate and tropic regions, but during the brief summer—with its long days and nearly continuous sunlight—some kinds of flies and mosquitoes are present in hordes. Insects found in one part of the polar regions are very similar to those found in another part. Butterflies, bees, and mosquitoes extend as far north as the northernmost land. Dragonflies are not found north of the tree limit.

*Salmon.*

## NATIVE POPULATION AND SETTLEMENTS

The polar and sub-polar regions are sparsely populated. There are about 17,000 Eskimos in Greenland, 9,000 in polar Canada and Labrador, and more than 4,000 in polar Alaska. In addition, there are a very few Indians. In sub-polar Alaska there are 11,000 Eskimos and 18,000 Indians and Aleuts. In sub-polar Canada there are 73,000 Indians, making a total of about 102,000 natives in sub-polar North America. The grand total of native population in polar and sub-polar North America is thus about 132,000.

Many of the natives are nomads. They move from place to place in search of food and furs. Since these people depend primarily on animals for their existence, and only secondarily on plants, they move with the seasonal migrations of animals which themselves are moving in search of food. Exceptions are the Eskimos of the west coat of Greenland, who maintain fixed winter settlements and disperse only for hunting in summer. With the coming of warm weather, the Eskimos of the Canadian polar shores move inland to hunt caribou in their summer feeding grounds and to get timber for tent poles and spears. Others seek salmon streams or the breeding grounds of ducks and geese. Hunting on land is, however, secondary. In the North American polar regions, man is predominantly an island and coastal dweller.

Many parts of the polar, and even the sub-polar wooded country, are almost uninhabited and are rarely visited even by hunters. Such areas include the interior of the vast Quebec Peninsula between Hudson Bay and the Atlantic Ocean, much of the interior of the Keewatin district northwest of Hudson Bay, the western part of Baffin Island and the islands directly north of Victoria Island and Banks Island. In Greenland, the north coast is uninhabited, as, of course, is the ice-covered interior. Not many communities in the polar region (except certain mining centers) have more than a few hundred inhabitants each. Most of the settlements are situated on large lakes or bays or at the mouths of the rivers. This has been caused by two factors. In the first place, the polar region has lacked roads, railroads, and, until recently, airfields, and the chief means of travel and transportation has been by boat. In the second place, most of the population subsists by fishing, sealing, whaling, and fur trading. Moreover, trapping and hunting are often best near lakes and rivers.

CHAPTER 5

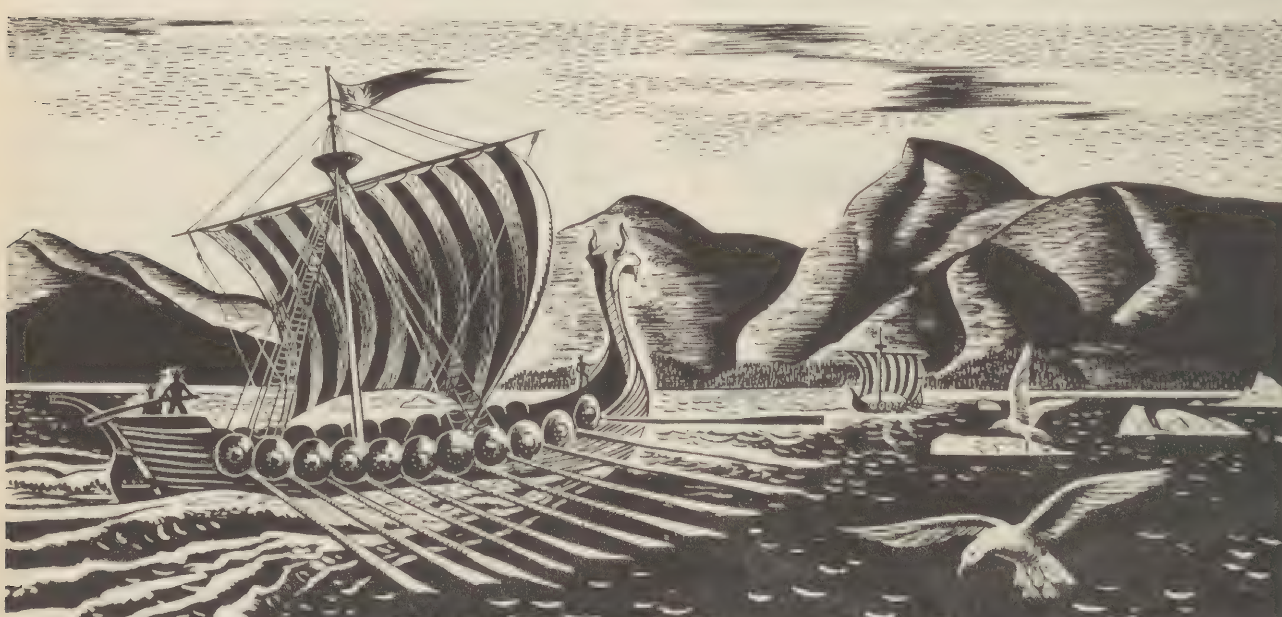
# HISTORY

No one knows who first discovered the polar regions, but it seems fairly certain that some people reached these regions long before the first explorer of whom there is any record. Evidence suggests that native peoples may have made their appearance in the North American polar regions as long ago as 20,000 or 25,000 B. C.

In history, the polar regions are first heard of through Pytheas of Massilia who, in a daring voyage during the year 325 B. C. came upon an inhabited land which he called Thule (probably Norway). From the people who lived there, he learned about a "congealed sea" (probably the Arctic Ocean) where sunrise followed sunset by a short interval. Thus it is apparent that Norsemen were already acquainted with the polar regions some 2200 years ago.

In the centuries that followed Pytheas' trip, Norsemen undoubtedly continued their wanderings throughout the polar regions, but there is no definite record of any particular explorer until the end of the ninth century A. D. when Ottar crossed the Arctic Circle and explored what are now known as the Barents and White Seas. The most famous of the Norse explorers were Eric the Red and his son Lief. Eric the Red in 982 A. D. discovered and settled what is now Greenland. His son, Lief, on a returning voyage from Norway, discovered a land he called "Vinland the Good" which later proved to be a stretch of the American continental coast. While the Norsemen made many voyages using varied routes, they followed no definite pathways. They merely spread out into the wide area of the unknown, led to the polar coasts probably in part by currents. They revealed no new routes to the polar regions and furthered polar exploration but little. It seems likely, however, that the Norse contact with North America did influence the voyages of Columbus and Cabot, the two pioneers in the Atlantic, and indirectly hastened the discovery of the New World.

Most of the voyages of discovery during the late fifteenth and early sixteenth century were more or less southerly. Only three led to the polar regions—those of Cabot, Fernandez and the Cortereal brothers. In 1497, Giovanni Caboto (English translation—John Cabot), reached Nova Scotia and Newfoundland and came in contact with polar ice. Joao Fernandez reached Greenland in 1500, and the brothers



Gaspar and Miguel Cortereal discovered Newfoundland (1500-1502).

The early voyages to the New World thus revealed very little about the polar regions, but in making Europe realize that the New World was a barrier to navigation between Europe and Asia, they exerted a tremendous influence on polar exploration by encouraging explorers to sail around the north coast of the New as well as the Old Worlds in order to find Asia (Cathay). "Northwest Passage" and "Northeast Passage" became the accepted slogans, and the search divided itself into two routes. The search continued for more than three centuries and brought forth many great explorers such as Frobisher, Barents, Davis, Hudson, Baffin, and Bylot. Their memories are perpetuated in the names of the straits, islands, and seas of the polar regions.

The first voyages were directed toward the northeast. A map of China by Sigismund Herberstein, which aroused the hope that China would be reached by sailing along the Siberian coast, and the founding of the Company of Merchant Adventurers, advocated by Sebastian Cabot (John's other son), led to a number of voyages. The chief result of these voyages was the discovery of Spitzbergen in 1596 by expeditions under the leadership of Heemskerk and Barents.

Before the northeastern voyages slackened, the northwestern ones started in full swing. Martin Frobisher, of Spanish Armada fame, led the way with three voyages to the territory now known as Baffin Land in 1576 and 1578 and brought from there the iron ore of the northwest as a new attraction. Later, John Davis made a real advance, reaching latitude 72°12′ North in Davis Strait. Henry Hudson's four voyages from 1607 to 1611 are notable in this series because of his discovery of Hudson Bay. Another notable voyage was that of Baffin and Bylot, who reached latitude of 78° North in the year 1616.

Not much exploration was done in the rest of the seventeenth and most of the eighteenth centuries. Seman Dezhnev, a Russian, passed through the Bering Strait in 1648, but his trip was unknown to most of the world, and the strait was not "discovered" until Vitus Bering repeated Dezhnev's visit in 1728. The Russians learned new facts about the Siberian coasts, and sealers and whalers made numerous trips in polar straits, but on the whole there were no outstanding discoveries during the late 1600's and early 1700's.


Nevertheless, the problem of the northeast and northwest passages had not been abandoned. In 1778, Cook passed through the Bering Straits looking for an ice-free passage. He failed to find it but did prove that the continents of Asia and America are distinct and separate and that there is a sea north of the Bering Strait. His report also made it clear that a passage which avoided the ice was not possible and that the only hope of finding a northern passage lay in pushing through the ice. Many expeditions tried to do this in the early 1800's but failed. The most noteworthy of these expeditions was that of W. E. Parry, who in 1818 reached Banks Strait, longitude 114° West, only to be stopped by impenetrable ice.

An uncle and nephew team, J. Ross and J. C. Ross came almost as near as Parry to the discovery of the passage in 1829, but they too failed. Another outstanding expedition that failed was that of Sir John Franklin, who sailed in 1845 in two ships, the "Erebus" and the "Terror," following the route of Parry. Although not one man in this expedition returned, it had a tremendous effect. Many expeditions sailing out in search of Franklin and his men explored the greater part

of the Canadian Arctic Archipelago and made important discoveries about the whole region. Yet, they too failed to find the northwest passage. It was not until 1903-1904 that the northwest passage was actually made. Roald Amundsen finally succeeded where so many others had failed. He took the ship "Gjoa" from the Atlantic to the Pacific, by way of the North. The northeast passage had already been made in 1878-1879 by A. E. Nordenskiold, who sailed the "Vega" from Europe to Japan by way of the Kara Sea along what is now a commercial USSR route. It had taken centuries of suffering to accomplish the passages, but as usual, once the great adventure had succeeded, it was repeated several times within a few years.

The centuries of arduous effort had, however, not been wasted. In the course of the search for passages, civilized man had discovered not only the lands and seas of the polar regions, but also the proper way of living there. The explorers learned that by living off the land they could travel light and fast and at the same time have a much more healthful diet than was possible through the use of preserved provisions. The expeditions also gave them wide experience in sledging and polar travel generally. This knowledge paved the way for more difficult and perilous advances upon the North Pole itself.

Baffin and Bylot had reached a latitude of 78° North in the year 1616, and Parry had advanced as high as latitude 82° 45′ North in 1827 by leaving his ship and traveling with sledges. No one had been able to travel further north because of impenetrable ice pack until, in 1893, Fritjof Nansen, convinced that there was a slow steady current across the polar basin from the Asiatic to the Atlantic side, decided upon a revolutionary scheme. Instead of fighting the ice pack, he let his ship "Fram" become imbedded in the ice, and he drifted from the New Siberian Islands to Spitzbergen in 35 months, reaching a latitude of 85°57′ North. By means of a sledge journey, he went up as far as 86°14′ North, setting a record which was not beaten until U. Cagni sledged north from Franz Joseph Land in 1900 and reached latitude 86°34′ North. The pole was finally claimed by Admiral R. E. Peary in 1909, after he had spent twenty-three years in the attempt.

The final chapter in polar exploration is being written in the air and is not yet completed. It started in 1897, when Andree made a disastrous attempt on the Pole by balloon from Spitzbergen. In 1925, Amundsen tried with a dirigible but proved only that steering was difficult and that consumption of fuel was greater than he had anticipated. In 1926, Byrd, with Floyd Bennett as pilot, reported the first successful flight over the North Pole, flying from and returning to Spitzbergen. Later that year the region was again crossed, this time in the semi-rigid airship "Norge", by Amundsen and Ellsworth. Since then, many polar flights have been made, especially from Ladd Field. Thanks to improved equipment and techniques, trips that were once thought dangerous have become an almost daily routine not only during the daylight period but also in midwinter darkness, enabling Air Force pilots to experience that dream of navigators—a celestial fix over the North Pole by star sights.

# PART 2

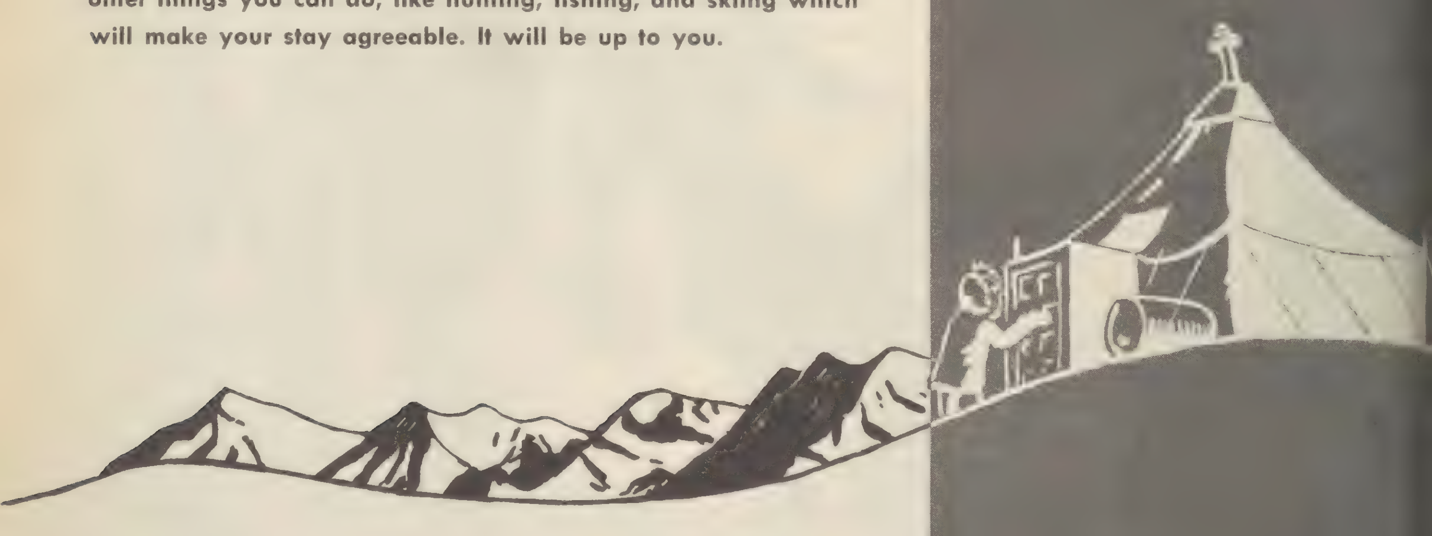
# LIVING

# PART 2

CONTENTS



Garrison life in the polar regions is much like garrison life in the United States. Your barracks may be different — Quonset and Yakutat huts are used as well as the standard two-story frame; your food may be of higher caloric content; and your clothing may be modified for climate; but on the whole, life will be the same. The jeep will be there, the same old cot will be there, and your friends will be there. Naturally, there will be certain inconveniences. Latrines are often some distance from the barracks, and on a cold wintry night, your visit may not be a happy event. There aren't many telephones. And your social life will probably be curtailed because after retreat, you are not going to be able to run into town. There aren't many towns. But there will be many other things you can do, like hunting, fishing, and skiing which will make your stay agreeable. It will be up to you.



CHAPTER 6

# FOOD AND WATER

## GENERAL

Every sound thing you learned about food at home applies in the polar regions. Food is needed for body maintenance and for fuel. The kinds and amounts you will need for maintenance are the same in the polar regions as anywhere else, but the amount of food you will need for energy will depend upon how much work you do and whether you spend most of your time indoors at a desk or outdoors in cold weather.

## FOOD REQUIREMENTS

Energy derived from foodstuffs is expressed in calories. Each calorie represents the amount of heat required to raise the temperature of about four pounds of water one degree Fahrenheit.

In temperate climates, a vigorously hard working man expends about 4,000-4,500 calories per day. Under polar conditions, however, there is a somewhat higher caloric requirement to meet the increased needs of energy expenditure and the maintenance of body heat. The actual daily requirement depends upon many factors, such as type of activity engaged in, weather, and physical condition. In spite of these variables it has been found that 5,000-5,500 calories is generally adequate except under extreme conditions of heat-loss. It is generally not necessary, therefore, to increase your food consumption greatly in the Far North.

Most of the calories in the usual diet are obtained from the so-called energy foods, the carbohydrates and fats. Carbohydrates, generally in the form of fruit or vegetable products, yield approximately 113 calories per ounce. In their normal state, they are usually high in mineral and vitamin content and represent a source of relatively quick energy. Fats yield approximately 225 calories per ounce. They have a negligible mineral content and, except in the case of milk products and fish liver oils, are usually low in vitamin values. The fats are readily stored and are burned less quickly than carbohydrates. They are utilized best when combined with an abundance of carbohydrate products, and they add "staying qualities" to the diet. Proteins yield approximately 113 calories per ounce, and when in the form of eggs, milk products, or glandular meats are rich sources of vitamins and minerals.

Proteins exert directly beneficial effects upon health, morale, and stamina. Regardless of caloric needs, a man of average stocky build, of about 170 pounds, requires a minimum of three ounces of protein a day to replace the wear and tear on muscle, gland, and nervous tissue. Under expeditionary conditions, however, it is desirable

CARBOHYDRATES

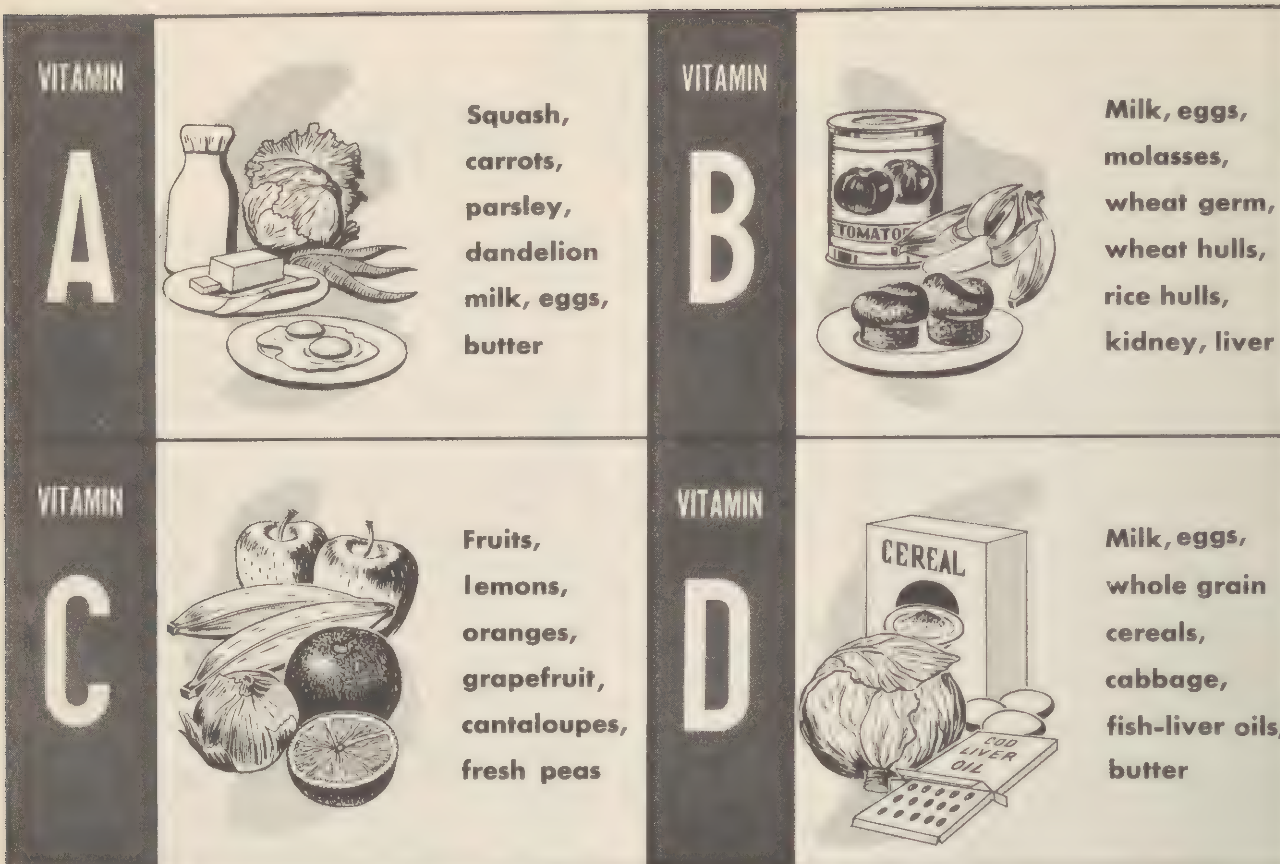

Fruits, vegetables, sugar, bread, syrup

PROTEINS

Meat, cheese, eggs, fish, legumes (beans, peas, etc.)

FATS

Milk, butter, eggs, bacon, nuts, fish-liver oils




to allow an ample surplus of protein in the diet as a factor of safety. Any excess is harmlessly eliminated. It is best to get protein from fresh sources. While some of the protein can be supplied by whole grain cereals, peas, beans, and the like, the most valuable proteins are those furnished by meat, milk, and eggs. When taken in the diet, the animal proteins increase the actual values of the vegetable proteins. Highly processed products are poor sources of protein, commercial gelatin, for example, being markedly deficient in certain of the essential amino-acids required by the body.

Calcium and phosphorous are necessary for many of the body's functions, such as normal nerve condition, heart beat, muscle contraction, and the like. A diet containing an abundance of milk, cheese, green leaf vegetables, whole grain cereals, and eggs insures an adequate intake of calcium and phosphorus. Iron and copper are necessary for the prevention of anemia, and digestive disturbances. Fair amounts of liver, molasses, sea foods, whole grain cereals, and dried fruit will prevent iron and copper deficiencies. Lack of iodine in the diet causes a slowing of body functions and of mental processes and a loss of energy. Iodized salt, now everywhere available, and sea food will prevent this deficiency. Any diet which is otherwise adequate will generally provide enough of the remaining essential minerals, such as sodium, potassium, sulphur, chlorine, magnesium, manganese, and zinc.

Vitamins, like the essential minerals, constitute only a minute proportion of the food you eat, but their role in the body is so important that the complete absence of any one of them almost invariably results in death. Here are the most important vitamins:

VITAMIN A occurs in thin green leaf portions of such vegetables as parsley, dandelion, and other greens. It is also present in squash, carrots, sweet potatoes, and apricots. Butter and fresh eggs are good sources of this vitamin, but the richest common source is in fish liver oils. Lack of vitamin A in the diet results in weak vision, skin disturbances, and destructive changes in the intestinal and urogenital tract.

VITAMIN B is a complex of several substances including vitamin $B_1$ (thiamin), vitamin $B_2$

(riboflavin), and niacin (nicotinic acid). All of vitamin B complex is found in milk, eggs, green leaf vegetables, liver, kidney, rice hulls, wheat hulls, wheat germ, and molasses. Lack of Vitamin B in the diet results in a variety of illnesses, depending on which one of the substances making up the complex is lacking. Deficiency of vitamin $B_1$ results in digestive disturbances and emotional unstability. Vitamin $B_2$ deficiency causes skin disturbances and reduces resistance to snow blindness and other visual disturbances. Deficiency of niacin causes a disease called pellagra which is characterized by soreness of the mouth and by digestive and nervous disturbances. Lack of other elements of vitamin B causes a pronounced lack of vitality, extreme fatigue, breathlessness, and fainting spells.

VITAMIN C occurs in lemons, oranges, grapefruit, and other citrus fruits. It also is found in vegetables such as cabbages, cantaloupes, turnip greens, fresh peas, tomatoes, and in the skins of potatoes. Lack of vitamin C leads inevitably to scurvy, which is characterized by discolored skin, bleeding gums and loose teeth, lowered resistance to infection and injuries, and general loss of bodily efficiency.

VITAMIN D is found in fish liver oils, and in irradiated whole dry milk. It is also produced by the action of sunlight on the skin. The lack of adequate sunlight in the polar regions makes exposure to ultra-violet lamps desirable because of the resulting vitamin D produced. Vitamin D deficiency disturbs the blood balance, causing defects of the teeth to develop and making it difficult for fractures to heal.

## SELECTING FOODS

If you live at an established Air Force station you need give little thought to your diet —Air Force dietitians have worked out the details for you. If you are not at an Air Force station, here is a simple plan for meeting your food requirements. Eat according to this plan and you will be assured an adequate diet. Should you modify the diet because of necessity or because you do not like some particular food, select alternates with the same food value. You need not eat every "essential" food every day; if you do not have meat one day, you can easily make it up the next.

MILK. One pint or more daily. Evaporated or powdered milk is just as good as fresh milk, nutritionally speaking.

EGGS. One or two per day. Dehydrated eggs have the same nutritive value as fresh eggs.

MEAT. One serving per day, preferably with some fat. Liver and fish at least once a week. If meat is scarce, eat an equivalent amount of similar foods such as fish, liver, eggs, or beans.

VEGETABLES. One or more yellow or leafy green vegetables lightly cooked, or raw in salads, at least once a day. Frozen or dehydrated spinach, carrots, peas, and other vegetables are as healthful as fresh vegetables provided they have been processed to retain most of their vitamin content. Do not use soda to brighten the color of vegetables as this destroys their vitamin content.

FRUITS. One or more servings daily, either raw or cooked. Citrus fruits and other fruits high in Vitamin C (anti-scurvy vitamin) are very important. Dried fruit and some fresh fruits furnish little Vitamin C but may be of value in the diet as sources of other vitamins, minerals, energy, and roughage.

REMAINDER OF DIET. Aside from these requirements, fill up according to the dictates of your appetite on additional energy-yielding foods—potatoes, beans, cereals, breads (preferably made with enriched flour), fats (preferably butter), and sweets. Do not be surprised at the size of your helpings—you need plenty of calories for hard work at low temperatures.

By eating a diet of good quality foods based on the plan given, you will have plenty of vitamins. Eating additional vitamins will not improve your efficiency. However, be particularly sure to get your daily requirements of vitamins B and C. These vitamins cannot be stored by the body, and are quickly oxidized and eliminated. Eat citrus fruits, cereals, and other foods containing these vitamins daily. If there is real doubt about the quality and vitamin content of the foods available, and you must live on such foods for several months, supplement your diet with vitamin concentrates. The attending surgeon will give you advice concerning vitamin concentrates.

With a diet having a full quota and proper balance of carbohydrates, fats, proteins, salts, vitamins, and water, you will be able to perform at maximum efficiency, but such a diet does not guarantee you abundant energy. The amount of work you get done on any diet will depend on your morale. If your efficiency seems to be slipping, it is probably your morale and not your

diet that needs attention. So make sure that you have plenty of recreation at all times.

In very cold weather and at isolated polar stations try to avoid monotony of diet. If you have to eat the same things day after day, you are likely to lose your appetite, and inefficiency may result simply because you do not eat enough. Of course, when there is plenty of outdoor work to do, your appetite will be good and you will eat enough food to take care of your bodily needs.

## CARE OF FOOD

The usual principles of food preservation and storage apply in the polar regions in the same way as in the States. One thing is especially important, and that is the need for preserving vitamin values, which are frequently lost by oxidation and exposure to light. To prevent this, store foods, insofar as possible, in dark, air-tight places. Leave the natural covering of the fruits and vegetables intact until you are ready to use them. In packing fruits and vegetables, a good way to reduce vitamin C loss is to put them in an air-tight container and put a lighted candle in just before sealing. Be careful with bread stuffs, such as graham crackers and cookies. They mold quickly even at low temperatures unless they are dry and tightly sealed.

### Summer refrigeration

Even in the polar regions, refrigeration of some sort is required during the summer to keep foods fresh. If you have no artificial refrigeration system, there are ways to develop natural ones. In many regions, the period of high temperature is limited to a few hours in the afternoon. If night temperatures are low, you can ventilate the house in which your food is stored by opening it during the night and closing it during the day. (Be sure to set traps for animal intruders.) If all of the snow and ice in your locality is likely to disappear during the summer, cut ice from a lake, river, or fjord during the winter and store it in an ice house. (Fjord ice tastes salty but is satisfactory for refrigeration.) To insulate the ice house, bury it or build it with double walls. Pack the ice in excelsior, peat moss, or similar material. In many localities, you can keep a small storehouse cool by circulating through it the water of a cold stream. The chill of the frozen ground itself is an excellent cold storage agent. If the ground consists of frozen soil and not rock, you can make a fine ice box by merely digging a hole, (with a pickax—a shovel will not do the job).

On the ice pack you can bury fresh meat in the ice for refrigeration. Be sure, though, that

you provide some sort of shade, for solar radiation will penetrate the ice and heat the meat enough to cause spoilage.

#### Winter Procedure

In places where regular facilities for storing food are lacking, the simplest way to preserve perishable foods in winter is to allow them to freeze. Bring into the kitchen and thaw out for cooking only as much food as you need for a single meal. Meat frozen and thawed two or three times is quite tasteless and watery. Fresh fruits, vegetables, and eggs can be kept frozen and in fairly good condition all winter, but they will deteriorate if they are allowed to thaw and freeze repeatedly.

Most canned foods can be frozen without loss of food value, although the flavor of some products may be affected. Occasionally, a can may burst in freezing. In such cases, the food may be spoiled and should not be eaten unless it is certain that the food has remained continuously frozen (without thawing and refreezing). Freezing does not harm powdered or evaporated milk. Evaporated milk that has been frozen curdles when added to coffee or tea, but it can be used for cooking. When frozen, home-baked bread keeps amazingly fresh. Cool the loaves first to allow the steam to escape, then wrap them individually in paper and set them out at once to freeze. Thaw a loaf only as you need it. If the thawing is done quickly in an oven, the thawed loaf is as good as fresh bread.

### COOKING

The flavor and digestibility of food is almost as important as its contents. Food that does not stimulate the appetite or is difficult to digest places a burden on the body's resources. By remaining unduly long in the stomach, such food not only loses much of its value but requires an abnormal amount of the body's energy to complete the digestive process. If you know, therefore, that you are going to a small outpost and will have to do your own cooking, it will be wise to take along a cook book. It may be even more important to select types of food that are not too difficult to prepare because of freezing and also to learn how to use a Primus stove efficiently.

The new, lightweight, stainless steel pressure cookers, if you can get them, are very advantageous, for they reduce the actual boiling time by eighty percent or more. This saves considerable fuel as the foods continue to cook while the

pressure is going down after the removal of the heat. More important, however, is the fact that quick pressure cooking keeps the loss of essential vitamin values down to a minimum.

Be careful not to overcook food, especially under emergency conditions, for overcooking may destroy essential vitamins and minerals.

Before you start on the trail, cook as much of your food as possible—that is, food like meat which does not absorb water in the cooking. In winter the food stays frozen and needs only to be heated. To heat frozen meat, cut it into small chunks and place them on top of pieces of ice or snow in the cooking pot. By the time the water has boiled a few minutes, the meat will be ready. If the snow is "dry" (that is, fluffy and absorbent), stir it occasionally to prevent it from absorbing the water at the bottom and so burning the pot. To save fuel, use hot pots or thermos flasks as fireless cookers for additional cooking, conserving their heat by wrapping them in grass, furs, or clothing.

WATER. The water obtained from melted snow is, of course, virtually distilled and quite free of minerals. Food cooked in such water has its mineral salts dissolved away and is very flat in taste. Adding a pinch or so of table salt to this water retards the leaching action on food minerals and improves the taste. You can also use reconstituted powdered milk in cooking to improve the taste and decrease mineral losses. Flavored powders, such as lemon powder and the like, are also helpful, for they contain Vitamin C and, in addition, improve the taste of the flat snow water.

MEAT. If it is possible for you to eat the meat in a frozen state, it will be much better, for it will save cooking. If you do wish to cook it,

thaw it before cooking; partly frozen meat may cook on the outside while the center remains raw. (While this is not entirely disadvantageous, as eating such meat may help you learn to subsist on raw meat, you may not like it.) In order to save the meat juices, quickly braise or pan roast the meat without puncturing the surface. Save the drippings and add them to other dishes. In general, it is better to have meat underdone rather than overcooked. If you suspect parasitic infestation, cook the meat thoroughly. Infestation, however, is rare unless the animal or fish is obviously sick.

VEGETABLES. Cook vegetables only until they are tender. Further cooking reduces their vitamin content. Cook them in the least amount of water feasible. This improves their flavor and prevents extensive loss of vitamins. You need not completely thaw out frozen vegetables. Simply drop the small frozen pieces into boiling water.

DRIED FRUIT. Soak dried fruit overnight in cold water. Simmer slowly in the same water until tender. Sweeten to taste.

## SOURCES OF WATER

During the summer, water is abundant in lakes, ponds, and rivers. Be sure to make river water safe for drinking by boiling it or by treating it with halazone or iodine. The milky water of a glacial stream will not hurt you. Let it stand in a container for a few hours, and it will clear up a little as its coarser sediment settles.

In the fall, you can get water from your summer water hole by removing the few inches of fresh ice formed each day. If the ice is not too thick, your efforts will be repaid by a good supply of water. To keep ice in the water hole at a minimum, cover the hole with snow blocks. On the trail, in an emergency, or when the supply freezes up solid, you will have to melt ice or snow to get your water.

From the viewpoint of ease of transportation and amount of attention required, it is better to melt ice than snow. Ice is denser than snow and yields more water per given volume. Moreover, you can put ice into a container over the fire and let it heat until it melts. With snow, you have to use more care. If you pack snow into a pail and put it on the fire, you may melt the bottom of the pail before you get water. Snow absorbs water and, if packed, will form an insulating air space at the bottom of the pail, reflecting the heat and resisting melting.

Remember, though, that it takes no more heat to secure a given amount of water from snow than from ice at the same temperature. You merely have to know how to do it. Start with only a little snow in the bottom of the container and then add the snow *slowly* so that the melt water always remains in contact with the bottom. After the bucket is about half full of water, allow the water to become warm and then add enough snow to fill the bucket to the top with slush.

When you use snow, get the most compact snow available. In camp, improvise a big metal reservoir behind a stove. A 55-gallon drum is excellent for this purpose. Place it so you can shovel snow into it directly from the outside. Empty and wash your reservoir thoroughly from time to time. Be particularly careful, of course, to keep dogs away from your supply snowbank.

Icebergs, being composed of fresh water, always yield fresh water. Sea ice is generally salty, but loses its salt with age. Although a large part of its mineral content is table salt, it also contains enough Epsom salts to produce disagreeable effects. Use it sparingly and only for cooking.

Last year's sea ice seldom has a noticeable amount of salt, while ice two years old is probably purer than the average spring or stream water. Fresh sea ice has a milky appearance and is angular where broken. The under-water part of old sea ice has a bluish appearance. It is rounded where broken and is likely to be pitted and have pools in it. In summer, these pools are fresh if they are far enough away from the edge of the ice not to be reached by the salt spray.

It's all right to eat snow if you use common sense. Do not swallow snow in lumps—let it melt slowly in your mouth. If you are cold, or hot and tired, go easy on eating snow. It will lower your body temperature and may make you more thirsty. Remember that the temperature of snow is approximately the same as the air temperature. If you try to eat snow at $-30°$ F, without first warming it with your breath or hands, you will freeze your mouth. In general, it's better to eat snow often and in small quantities rather than to wait until you're thirsty.

CHAPTER 7

# CLOTHING

## KEEPING WARM

Most newcomers to the polar regions tend to overdress for outdoor work in very cold weather. Don't bundle up in all the underwear, shirts, coats, and sweaters you can find. By the time you have all this on, you'll hardly be able to move, and you won't be as warm as you might expect. Wear enough to be comfortable, but be ready to take off clothing, especially if you begin to sweat. Dress according to the weather and the way you feel rather than by the thermometer or your fear of being cold. Pay attention to details of your dress rather than the total quantity you put on.

Many types of cold-weather clothing have been tested and approved for issue by the various government agencies. They are too numerous, however, and too frequently changed as a result of research and experience, to be discussed here. What is important about clothing is its usage and adaptation rather than its specific types.

In general, your success in keeping warm will depend on how well you learn to conserve body heat and keep from sweating. This involves an understanding of how your body heat system works and how you can conserve heat through accustomization to cold skin, proper dead air and clothing insulation, and avoidance of sweating.

### Body Heat System

Your body is very much like a gas engine. The food you eat is the "gas". When this energy is burned by the different tissues in the body, such as the muscles or the brain, part of the energy is used in doing work, but most of it is liberated as heat. The lungs are the carburetor, intake, and exhaust through which the oxygen is drawn in, mixed with blood, and the waste gas (carbon dioxide) eliminated. The heart and blood are the fuel pump and line; they force the absorbed food and oxygen around under pressure. The surface of the body is the radiator, and, as in any other radiator, the parts that have the most surface in proportion to thickness cool off the fastest. Thus, the arms and legs (especially the hands, feet, fingers, and toes) and the ears, nose, and chin dissipate a large part of the heat generated in the body. This whole heat system is automatically controlled by an involved thermostatic system.

When you exercise or do work, you burn up more "gas" (food stored in the muscles), more air is needed, and you breathe faster and deeper. Consequently, more heat is generated, and the small blood vessels near the skin open up wider. There is then greater circulation in the radiator (skin), and the heat loss is faster. In cold weather, when the normal rate of heat loss would result in excessive cooling, the circulation in the radiator (skin) is cut down by constriction of the small blood vessels. This reduces the rate of heat loss and preserves the heat for the vital "innards".

Down to about $-60°$ F, this system works fine. Below that temperature, however, the reduction in circulation (and heat distribution) to the radiators causes those parts of the body that are the most efficient radiators to cool down to nearly air temperature. As a consequence, such parts of the body as fingers and toes are the first to become frostbitten and to freeze.

Obviously, the manner in which this system operates indicates that in the polar regions you must become accustomed to a cold skin in order to keep the temperature difference between the skin and the air (and the rate of heat loss) as small as possible. In the second place, since the amount of heat supplied to the extremities is considerably reduced when the body becomes cold, you can do as much to keep your fingers and toes warm by keeping your body warm as by putting on more gloves and footgear.

### Conservation of Body Heat

As just explained, you have an efficient central heating system that will keep you warm at any air temperature, provided its loss of heat does not exceed its heat production. The problem then, is chiefly one of preventing the loss of body heat.

To a limited extent, the body automatically controls its heat loss through control of blood circulation in the skin. At low temperatures, however, this is totally inadequate, and you must provide additional insulation to keep heat losses down. This insulation takes two forms—dead air space and clothing.

DEAD AIR SPACE. The layers of dead air between the different layers of your clothing constitute more important insulation than the fabric itself. Look at the ptarmigan, for example. His fluffy feathers hold many tiny pockets of dead air which slow down the escape of heat from his body. By raising or lowering his feathers, he can increase or decrease the dead air space around his body, control his heat loss, and make himself warmer or colder, as necessary.

Follow his example. Make sure that the fit of your clothing is such that you have adequate dead air insulation. Don't get clothing that is too tight—and remember that it will probably shrink when washed. The best fitting is one that allows about one-fourth inch dead air space between each layer. This means that each garment should be sufficiently larger than the one underneath it to allow about a quarter of an inch of space between the two. For most clothing, an outer garment should therefore be approximately three inches greater in circumference than the garment underneath. Air Force clothing is designed to provide this extra circumference. Thus, a size 40 over-garment is approximately three inches larger in circumference than a size 40 under-garment.


Be particularly careful in judging the fit around the joints—shoulders, elbows, hips, and knees. If your clothes are not large enough, the pressure resulting from your movements will squeeze out the valuable insulating air and may shut off the blood supply there, making those areas much more likely to freeze.

On the other hand, remember that if your clothing is much too loose you can leak heat the way a garden hose leaks water, and you can lose enough heat that way to make you chilled and uncomfortably cold. The places at which you are most likely to leak heat are at your neck, wrists, waist, and ankles. At your neck, a woolen scarf and tightened parka drawstring will stop the leakage; at your wrists, knitted wristlets under your sleeves and gloves will help; at your ankles, enough socks and properly worn pants will do the job. You can protect your waist by a drawstring, a belt, or elastic, depending on the type of parka you wear. Make sure, also, that there are no buttons missing on your underwear (if it's the kind that needs buttons) and that your fly opens and closes easily.

CLOTHING INSULATION. The results of the continuous program of research directed toward improving the insulating qualities of fabrics are showing up in progressively better clothing. In the final analysis, however, the insulating qualities of the fabrics in your clothes depend largely on your treatment of them. Among the most common causes for the reduction in insulating qualities of fabrics are dirt and moisture.

Keep your clothing clean. Greasy spots are good leaks because the grease fills up the pores of your clothing, making those spots more nearly solid, and therefore good conductors of heat. Other types of dirt act in a similar manner.

It is very important, also, to keep your clothing dry. Water draws off heat about twenty times as quickly as air and, if your clothing gets wet, it won't be long before it is solid with ice. Therefore, brush frost and snow off your clothes frequently, especially when entering

*Air Mechanic's Winter Uniform.*

houses or shelters. In fact, it's a good idea to have a whisk broom hanging outside the door to make this brushing more convenient.

Because of the fact that wind increases the rate of cooling considerably, it is particularly important to wear a windproof outer garment of clothing. The summer flying suit, for example, is useful for this purpose, for it is windproof and snow does not cling to it readily.

PREVENTING SWEATING. Sweating in the polar regions in winter can be deadly. The sweat will freeze—either on your skin or your underwear—and then *you* may freeze. If, during exertion, you begin to sweat or get too warm, loosen your clothing for ventilation or take off some of your clothing. You will find that your body can absorb enough heat on sunny days so that even at fairly low temperatures you may have to strip off a substantial amount of clothing to keep from sweating. Be ready, however, to put your clothing back on if the sun gets behind a cloud or if the wind comes up.

## TYPES OF CLOTHING

### Windproof Parka

No polar wardrobe is complete without a parka. This classic garment comes in either pullover or overcoat style and hangs down to the hips or even lower. All parkas have hoods. On some models, the hood is trimmed with dog, wolf, or wolverine fur. The parka may have

*Windproof Flying Suit.*

Airman's Winter Uniform.

Winter Vest.

drawstrings at the neck, wrists, and waist. It may consist of two layers or shells—wool inside and windproof cloth outside—or the two layers may be separate garments.

**Head Protection**

The parka hood is designed for head protection against the cold, extending past the face so that it may be pulled forward on the windward side. It collects the warm air rising from the body and tends to hold it a while. A front lining of wolverine is good because the frost that forms can easily be brushed off if you don't let it accumulate too long. A loosely fitted knitted wool headband across the forehead and over the ears is desirable if it is not too tight. Face masks are excellent protection in many types of situations as, for example, in the prop wash or for a short time in an emergency. Over a long period of time, however, they ice up. If it is necessary to cover the lower part of your face, use windproof material. Cover your face, as shown in the illustration, and as ice forms on the cloth, shape it as a cup away from the face. This will protect your face, for it will cover the lower part and it will direct the warm air from your breath over the top of your face where it is needed.

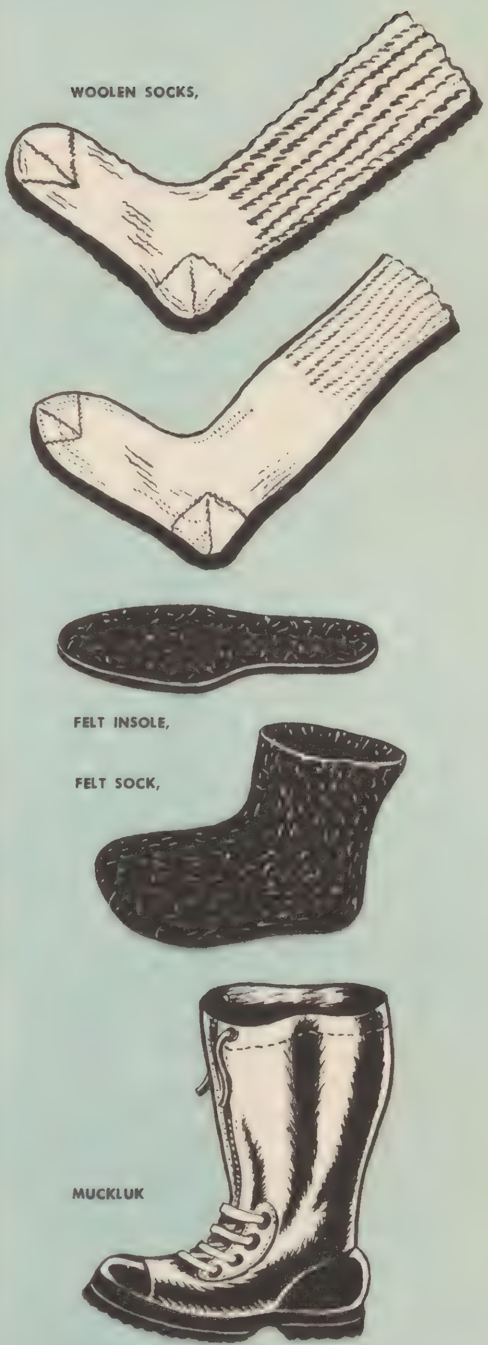
*Use Face Protection.*

**Footgear**

Your outermost winter footgear must be large enough to hold two to five pairs of woolen socks, thick insoles of felt or burlap, *and your feet.* In fact, you should have a little room left over. If you can surround your feet with materials which are comfortable and yet springy enough to hold thin layers of dead air, your feet will be warm even when the mercury drops out of sight. However, do not expect socks with holes in them, or dirty socks, to keep your toes and heels warm.

Shoepacs are fine in wet snow and above-zero weather, but mukluks or felt boots are more desirable when weather is cold and the snow is dry. Don't wear Blucher boots. Well-tanned leather gives very poor insulation.

With mukluks wear several pairs of socks. Many airmen have found the five-pair polar sock assembly satisfactory—a lightweight woolen sock next to the foot drawn up over the winter underwear; then three more woolen socks, at least two of them heavy; a felt sock; an insole; and the mukluk itself. With such an assembly you may tuck your trouser leg inside the mukluk, between two layers of socks, or better, tie your trousers over the mukluks.




WINTER FOOTGEAR ASSEMBLY

It is more important to keep your footgear dry than probably any other part of your clothing. At permanent stations, hang your footgear upside down near the ceiling where it can be dried sufficiently by the rising warm air. If you leave it on the floor, drying is much more difficult and sometimes does not take place overnight. It is important, too, that you have a change of socks every six to eight hours, for perspiration destroys their insulating qualities.

Don't keep your socks on when you go to bed, especially in a sleeping bag. Sweat will ruin their insulating qualities. If they are available, and you need socks while you sleep, use the double pile sleeping socks. In any event, always have an extra set of socks with you so you can change to a dry pair when those you wear become damp.

*Mittens.*

#### Gloves

Remember that your fingers and hands will freeze to metal tools at sub-zero temperatures if you touch them barehanded. Wrap tools with tape or cloth. Perspiring hands are really dangerous because they are easily frozen. Keep your hands dry! Don't wear damp gloves!

Gloves present a real problem. You not only have to keep your hands warm, but you must also be able to make fine adjustments with any sort of tool and do other work involving the nimble use of fingers. The best gloves available at present for mechanics are the issue five-finger gloves with a woolen lining. At extremely low temperatures, you can draw on a woolen mitten (gauntlet type) over these gloves for a quick warm up when your hands get cold. The quickest way to warm your hands, though, is to pull them out of the glove far enough to permit you to make a fist within the glove. In case you have very fine work to do, wear a rayon insert under the five-finger glove. With this insert, you will be able to draw your hands out of the glove and use them for fifteen to thirty seconds at a time in very fine work.

In selecting gloves, go by their fit, for their size may be misleading. With gloves as with other clothing, looseness is most essential. Don't get gloves that are tight.

CHAPTER 8

# MEDICAL PROBLEMS

## INSECTS

In the polar regions, the word "flies" has a special meaning. It refers not to house flies, blue bottle flies, and other such relatively inoffensive and friendly creatures, but to insect pests that come after a man in savage hordes, usually two or three kinds at once, intent on drinking his blood. "Flies" include mosquitoes, black flies, deer flies, and midges. Flies have been called the curse, the bane, and the scourge of the polar summer. That they deserve this description will be readily admitted by all who have spent part of June, July, or August in the north woods or on the tundra. They are the foe of both man and beast. During the long bright days, when twilight hours are few, they know no rest. Always on the lookout for a meal of warm blood, they swarm about their victims, centering their attack upon exposed skin or places where the hair is thinnest. There they alight, probe, and bite away until a hand slaps them, a strong wind blows them off, or a chill rain disposes of them. Only with the end of summer does their onslaught stop. Mention flies to a seasoned North countryman, and he will give a special scowl as he adds his bit to the opinion that has piled up through the years. "Why, I've had flies on me so thick that you couldn't tell the color of my clothes," he begins . . . and he's off. By the time he's finished, you wonder what he means when he speaks of loving the polar regions.

### Description

MOSQUITOES. These need no description—you'll know them.

BLACK FLIES. These are small, black, stout-bodied, hump-backed flies, sometimes called buffalo gnats or (erroneously) sandflies. Their bites stay open and continue to bleed for some time. They attach themselves especially at the collar line and inside the clothing where the belt binds the waist. They are less abundant north of the tree-limit than south of it.

DEER FLIES. These are large, strong-flying pests with banded wings. They bite ferociously the instant they alight on the bare skin and on hot days they follow a person persistently, even in a stiff wind. There are several kinds, and their names vary locally. They are also known as gadflies. Other flies in the same family are moose flies. These are larger, sooty black flies also called horseflies or bulldogs. The last term is peculiarly apt in view of their tenacity and the size of the hole they drill in the skin.

MIDGES. These are minute flies about one twenty-fifth of an inch long, known as "no-see-ums", "punkies", "gnats", and even "creepin' fire". They sink their tiny biting mouth parts into the skin, causing a sharp, burning pain all out of proportion of their size. Some of them are about the color of human skin and are very hard to see on the arm or hand.

Black fly.

Midge.

Mosquito.

Deer fly.

**Characteristics**

Mosquitoes, black flies, deer flies, and midges don't resemble each other in general appearance, but they are alike in several significant ways. They all bite—that is, they do not sting, as bees and wasps do. They do not generally carry diseases. They are primarily daytime insects. In more southerly regions, mosquitoes may not come out in numbers until evening, but in the Far North they seem to prefer daytime, especially the afternoon. If it turns cold, they become inactive, even when they are abundant. Only the females bite. (This is an interesting fact from which you may derive a dubious comfort.) During their larval stage, they live in water. All these pests have their natural enemies. As adults, some are captured occasionally by birds, spiders, and such predatory insects as dragon flies. As larvae, some are eaten by birds, small fish, and certain aquatic insects. As eggs and as pupae, they are fairly safe from molestation because they are motionless.

**How Flies Attack**

Each of the fly families has its own method, manner and time of attack. They exhibit the following attack characteristics.

Mosquitoes are not bothersome on cold nights, but the coolest summer nights are so short in the polar regions that they furnish only brief periods of respite. Mosquitoes are discouraged by a strong wind, however, so if you can stay near the coast, or on a peninsula, where there is a sea breeze, you may remain comparatively free of the pests. The worst days are the warm, quiet ones with a gentle land breeze. Then, for hours at a stretch, the unrelenting attack continues, especially in the afternoon. While the mosquitoes seem to prefer dark places, and will settle on dark clothing in preference to light, they do not seem to mind the direct sunlight.

Black flies prefer hot, sunny, dry days and are especially bothersome in June and July. They become quiet in cool weather and are never troublesome at night. Unlike mosquitoes, which usually fly from one point of attack to another, black flies run nimbly about like tiny bees, looking for openings in the clothing. When they get inside a man's shirt they gather at the waist in a greedy row or crawl down to the boot-tops. By evening, it is not uncommon to find your middle encircled with a row of open bites to which blood-stained underclothing sticks. If you have no head-net, black flies will attack the collar-line savagely. A handkerchief will afford slight relief.

Deer flies and mooseflies are lovers of sunlight, warmth, and moisture. Cool weather discourages them, and they are not as annoying on cloudy days or after sunset. But they can be very bothersome even in windy weather as long as the day is warm and bright. They will follow mile after mile, flying in the shelter of your head, winging round and round, striking your face, especially about the eyes. Their bites swell considerably.

Midges are irregular in distribution, but locally they can be terrible pests. They bite chiefly in the evening and early in the morning, and may be very bothersome on cloudy, sultry days. They are quickly dispelled by cold weather.

**Protective measures**

It is one thing to slap a mosquito now and then on a warm summer evening in Ohio—but quite another thing to run from a cloud of polar mosquitoes and black flies so thick a man can scarcely see through them. Don't be foolhardy enough to think that you're tough enough to get along without a headnet. You owe it to yourself, and to the work you must accomplish, to avoid bites, the danger of infection from scratching, and the wear and tear on your nerves, by making certain that a good headnet and gauntlet gloves are part of your equipment.

HEADNETS. Headnets must stand out from the face so that they do not touch the skin. It is most practical to wear them over a fatigue hat. You can sew them to the brim of your hat or attach them with an elastic band that fits around the crown. They should be made of the best grade of fine-meshed bobbinet (at least 18 meshes to the inch). Ordinary mosquito netting is not suitable for headnets, because it is not tough enough. Black is the best color, for you can see through black more easily than through green or white. At the bottom, there should be a strip of tough cloth encasing a drawstring, for tying snugly at the collar. Hoops of whalebone or ratten, or a broad coil of lightweight flat steel wire fastened on the inside, will make the net stand out from the face and at the same time allow it to be packed flat. Headnets are hot and disagreeable at best. The larger they are, the better the ventilation. But very large nets will not do for wooded country where they may become snagged on brush. Some nets are provided in front with a celluloid window. Others have a special opening for a pipe. The most durable and airy ones are made of wire screen, with cloth and draw-strings at the bottom.

GLOVES. Gloves are hot, but are a necessity where flies are really numerous. Old kid gloves with a 6-inch gauntlet closing the gap at the wrist, and ending with an elastic band halfway to the elbow, are best. For fine work, kid gloves with the fingers cut off are good. This requires a liberal use of fly dope on your fingers. Cotton work-gloves are better than no protection at all, but mosquitoes will bite through them. Treating the gloves with a creolin solution will help.

CLOTHING. It is well to bear in mind that mosquitoes do not often succeed in biting through two layers of cloth; hence, a lightweight undershirt and long underwear will help. To protect your ankles, tuck the bottoms of your trousers into your boots, or wear some sort of leggings. Tests show that light-colored clothing is better than dark. Navy blue, red, or black are apparently more attractive to mosquitoes, perhaps because they make the pests almost invisible to their enemies or because darker colors have greater capacity to absorb heat. The white camouflage or suntan clothing now issued by the Air Force is one form of protection against flies. Tan-colored socks offer less likelihood of ankle bites than dark socks. If you lose your headnet, make the best of a bad situation by wearing sun glasses with screened sides, plugging your ears lightly with cotton, and tying a handkerchief around your neck.

It is a good idea to spray your clothing with aerosol insecticide at night—it will help a lot to keep out no-see-ums during the day when you are working.

FLY REPELLENTS. Fly dope will help keep the pests away. One of the best new preparations is dimethylphthalate, now being used by the Air Force. It gives good protection for a little less than two hours after application, even when you perspire liberally. Various other mixtures have been used from time immemorial. Many a fisherman, woodsman, and explorer has evolved his own favorite recipe. Many home-made preparations can be used when a regular repellent is not at hand. Those containing oil of tar are the most effective.

TENTS. Tents should have a complete cheesecloth lining or bobbinet curtains at the front if they are to provide real comfort. Ordinary mosquito netting is not satisfactory. Cheesecloth with a circular or oval opening that can be closed with drawstrings may be sewn into the front of the tent. A bobbinet curtain, weighted

PROTECT YOURSELF

with shot at the bottom so that it will hang to the ground serves the same purpose. To be flyproof, the tent must have a complete cloth floor, or a foot-wide cloth extension, which may be held down with sod, extending inward from each wall. A tarpaulin laid over this extension makes an extra-tight floor. There must not be the slightest rip or hole in the tent, as mosquitoes quickly find openings of this sort. Before entering, brush the flies vigorously from the front of the tent and from your clothing.

BEDS. Make the beds flyproof if the tent is not. Bobbinet is best. Make certain that the net will be held away from the face and body of the sleeping person (nets should be held from the sides of the bed). A net covering the whole bed or sleeping bag is more satisfactory than one covering the head only.

To keep no-see-ums out of the bed nets during the day, spray the nets with aerosol insecticide and put them in an air-tight bag. Spray the beds

and nets at night again, for no-see-ums can get through the nets.

SMUDGES. Smudges when properly made will furnish relief for a short period. For a good smudge, clear away all debris and humus down to the mineral soil to prevent ground fire and build up a brisk blaze of dead wood. Let this burn until a bed of coals is formed. Meanwhile gather a supply of additional fuel as well as a mass of green ferns, leaves, twigs, damp leaf mold, and rotten wood. Place new dry wood on the coals and allow it to burn up brightly, then cover the whole fire with part of the green material. The dense smoke that now arises will banish the black flies instantly and repel most of the mosquitoes.

Built in a pail or pot, a bucket smudge is very useful since it can be moved easily in case the wind changes, or can be taken inside a tent until the flies are driven out. Put about two inches of sand in the pail before starting the fire. When you take a bucket smudge inside, be very careful to prevent setting the tent on fire.

Of course, if you are not an expert on smudges, they will probably run you out of the tent faster than the flies. Moreover, they constitute a fire hazard. Consequently, the best method is an aerosol insecticide bomb.

SPRAYING. Fumigation is a means of killing flies. Burning powdered jimson weed in a tent will stupefy mosquitoes without injuring human beings. The jimson weed is most effective when 8 ounces of it, mixed with 2½ ounces of saltpeter to facilitate burning, is allowed for every 1,000 cubic feet of tent interior. Commercial fly spray is also good. Be careful not to strike a light after spraying a room, since an explosion may occur.

The most convenient lethal spray for use indoors is the aerosol insecticide dispenser. Operation for a few seconds is sufficient to kill all mosquitoes in a pyramidal tent, and one dispenser will suffice for 200,000 cubic feet. This spray is non-inflammable and will not harm human beings.

FOOD. Keep all food covered, especially meat, as long as insects are prevalent, and don't be too hasty in stopping these precautions. It is surprising how late in the fall insects are around.

### Treatment of fly bites

Soaking in soapy water is the easiest and best all-round treatment of fly bites. You may use cold wet compresses made with baking soda, ammonia, glycerine, alcohol, iodine, moist soap, and even naphthalene moth balls. You can relieve the itching with calamine lotion.

As has been previously pointed out, black fly bites may stay open and continue to bleed for some time. There is, consequently, real danger of infection, especially from scratching. Occasionally, on a hot day at the height of the black fly season, a badly bitten neck will swell noticeably. Careful bathing in cold water, plus application of a wet compress will reduce this inflammation.

### Fly control measures

Can these flies be exterminated? The answer is—No—not in the polar regions; these regions are too vast. There is too much shallow water and other favorable breeding places. You may cut down the local abundance of black flies slightly by keeping streams free from obstruction and spraying DDT by plane. The larvae cling to rocks, roots, and fallen branches which accumulate at riffles. However, black flies breed only in swiftly flowing streams; avoid camping near them in black fly season. On the tundra, where innumerable ponds meet the eye in all directions, the situation is hopeless with regard to mosquitoes. Here, there is actually more water-surface than land surface. Most of the water is ideal for mosquitoes, for it warms up promptly in the spring. For every pool you can cover with oil there are a thousand you can't see. For every wriggler you can destroy, ten million will survive. The best you can do in this sort of place is to put on your headnet, line your tent with cheese-cloth, use repellents and sprays, and face the quiet summer days with as stout a heart as possible.

## FROSTBITE

Frostbite is the freezing of some part of the body. It is a constant hazard in sub-zero operations, especially when the wind is strong. Frostbitten skin becomes whitish and the flesh becomes stiff. As a rule, frostbite causes numbness rather than pain. The parts that are most easily affected are the cheeks, nose, ears, chin and forehead, wrists, hands, and feet. Prevention is a matter of taking proper precautions. If and when vou become frostbitten, thaw the frozen parts promptly. Neglected frostbite ultimately causes gangrene.

Frostbite may be classified according to its degree of severity. First degree frostbite is a

superficial freezing which results in no loss of tissue. It usually covers a small area with a waxy white skin discoloration. Second degree frostbite is a moderate freezing of tissue which results in the loss of only the superficial layers of skin. Its appearance is much the same as that of first degree frostbite. Third degree frostbite is a deep freezing of a relatively large amount of tissue which results in eventual death and loss of tissue deeper than the superficial skin layers. During the frozen stage, a third degree frostbite appears the same as the second degree, although it is of a much greater extent. Upon thawing, there is mottling, and evidences of gangrene often appear early. The amount of pain is no indication at all of the severity of the frostbite.

#### Causes

Frostbite is caused by exposure to severe cold, particularly in wind. Contributing factors are loss of body heat and poor blood circulation, the latter a condition occurring naturally or caused by overtight clothing. Clothing that is wet, either because of external causes or sweat, is especially dangerous. Insufficient clothing also adds to the risk. Further important contributing factors are shock, extreme fatigue, improper diet, and excessive carbon monoxide.

#### Treatment

The sooner you begin treatment of a frostbitten part the better. Treatment of first degree frostbite requires no procedures other than simple thawing of the part that is frostbitten. Where it is possible, the best treatment is exposure of the involved parts to air at approximately 70° F. In the field, thaw minor frostbites of the face by holding a warm bare hand against it. To thaw a frozen wrist, grasp it with your warm hand or stick it inside your pants. Thaw frozen hands against your chest, under your armpits, or between your legs at the groin. If you need to thaw a frostbitten wrist, ear, or parts of your face, and your hands are cold, warm them first as just described. Thaw frozen feet by holding them against a companion's belly or between his thighs. Change to warm, dry, footgear or, if these are not available, remove the cold shoes and socks and wrap your feet with skins or sleeping bags.

Treat second degree frostbite in the same manner, but protect the injured area by dry, loose, sterile bandages and foot cradles where necessary. Place the injured area in a comfortable position, but never immobilize it by the use of pressure dressings. Elevate frozen limbs slightly to help the circulation.

You may treat third degree frostbite in the same manner, but of course gangrene is usually a complicating factor and treatment will definitely involve medical assistance. Recent methods of treating third degree frostbite, such as the use of decoumoral, heparin, histidine, and sodium ascorbate have not been sufficiently tested to permit strict evaluation of them. Even medical officers should use them only when they have strict and accurate laboratory control facilities and experience in their use.

*Thawing Hands.*

*Never rub a frostbite.* This breaks skin tissue, causing open wounds, and in sub-zero temperatures wounds heal very slowly. Bending frozen arms, legs, or ears also breaks skin tissues. *Never apply snow or ice—they increase the freezing.* For the same reason, never warm frozen limbs in kerosene or oil unless you know their temperature accurately, as these liquids may be so cold that they will increase the frostbite. On the other hand, do not get too near a hot stove or other source of heat or use hot water to thaw a frostbite. Too rapid thawing increases pain and damages skin tissues.

When frostbite is accompanied by breaks in the skin, put an ointment like boric acid or vaseline over them and cover with a loose dry, sterile bandage. If infection continues, you might have to take sulpha medicine orally, as directed by a physician.

PROTECT YOUR EYES

Wear colored glasses constantly — Glycerin will partly prevent clouding — Blacken the face around the nose

A burning sensation like that of sunburn follows the thawing of a frozen part, and the treatment following the thawing is the same as that for sunburn. The thawing of serious frostbite may be very painful. Do not break the blisters that sometimes develop—a medical officer should open them. If they happen to break, trim off the dead skin with scissors and treat them as you would an open wound or burn. Always report to the Dispensary for any degree of frostbite. To soothe post-thaw burns, apply a good burn ointment, preferably lanolin.

**Prevention**

Keep your clothes loose to allow free circulation of air. This keeps them dry, and is the most important method of frostbite prevention. Protect yourself as much as possible from wind blast. Be careful also not to become overly fatigued and lose your body heat reserve. Avoid becoming over-heated, for excessive sweating means soaked garments. Should you get wet, change as soon as possible to dry apparel. When you do heavy work, loosen your clothing and throw your parka hood back. During the pause, however, put on extra clothing to prevent chilling.

At all costs, keep your feet and hands warm and dry. Your shoes or mukluks should be big enough to allow two to five pairs of socks without binding. Insoles of felt or senna grass contribute to dryness. When you make camp, change at once to dry footgear and lie so that your feet are nearest the fire. Wear heavy wool mittens with outer mittens of windproof cloth (such as canvas).

There is some dispute as to the advantages and disadvantages of wearing a beard. Some feel that it helps because it serves as external insulation; others that moisture from the breath collecting on it converts it into a virtual ice mask. It probably depends on your own individual preference and the size and thickness of the beard you grow. If you wear a beard, keep it clean and combed. If you don't wear a beard, clip your facial hair rather than shave. When it is necessary to shave, you can avoid chapping by shaving before going to bed rather than in the morning and by applying a thin film of lanolin to your face to restore natural oils.

To guard against a frozen face, wear a parka hood that projects well beyond your face; you can adjust the hood to shut off the wind. You can protect your face also by the use of a wind proof cover over the lower part of it, as described on page 7-4. "Make faces" from time to time and touch your face to test for stiffness. Also watch your companions' faces for tell-tale spots. To maintain good circulation in your ears, press them forward now and then.

Keeping in tip-top physical condition through adequate rest and proper diet is a major frostbite preventative. Alcohol increases the risk of frostbite because it seriously disturbs a

man's judgment, his body's normal heat production, and its control of body temperature. Never drink alcohol before going out into the cold. As far as satisfying warmth is concerned, a cup of hot chocolate will go further.

### COLD EXPOSURE

Cold exposure, sometimes termed advanced general freezing, is evidenced by muscular weakness, fatigue, stiffness of limbs, and overpowering drowsiness. The victim's sight grows dim; he staggers, falls, and becomes unconscious. If pulse and respiration are detectable, recovery is possible even though the body is rigid.

It used to be thought that treatment of cold exposure consisted of a very gradual rewarming of the body. Lately, however, it has been discovered that the best treatment is rapid—not gradual—warming. The victim has suffered a loss of the body heat reserve, and warmth must be restored immediately to help him recover. The best treatment, therefore, is hot baths and hot stimulants. An effort must be made to bring the patient back to normal body temperature as rapidly as possible. Such treatment is vital even when the patient hasn't been thoroughly overcome by cold exposure. Thus, if a person has been frostbitten after having been out for a long time in the cold, it is better to treat him for the cold exposure first, then for the frostbite. A simple and thoroughly reliable method for determining whether a person suffers from cold exposure—or *hypothermia*, the medical term—is to take his oral temperature. If it is below 96°, treat him for cold exposure.

All the frostbite preventatives apply as well to hypothermia. Proper clothing and good physical condition are particularly important. Clothing that is adequate, loose, and dry helps to retain body heat. Eating well and getting enough rest are equally important in preventing the rundown physical condition that invites the risk of freezing to death.

### SNOW BLINDNESS

Snow blindness is both very painful and wasteful of time but with proper care you can prevent it. Make every effort to avoid the first attack, because it makes you more susceptible to others. Recurrent attacks may permanently impair your vision. In the polar regions, delays are serious and often dangerous. For this reason alone, a snow-blinded person is a liability. With a slight attack, he must lie over for at least a day. A severe attack means a longer halt. The victim's usefulness, moreover, is reduced even after he is again able to travel.

The cause of snow blindness is an overabundance of light produced by reflection or glare from snow. Overcast days as well as sunny ones are snow-blinding days; so also are days of light fog. Keep in mind that snow blindness may result from very short periods of exposure to glare. During overcast days, there is multiple reflection back and forth between the cloud ceiling and the snow, and there are no shadows, causing the ground to look level. This causes straining of the eyes and makes them more susceptible to snow blindness.

If your eyes feel sandy, burn, grow red, fail to focus properly, and become increasingly sensitive to light, stop using your eyes. These are the first symptoms of snow blindness. Sometimes, you may not have any symptoms during the day of exposure but may be awakened by a terrific headache about three o'clock the next morning. The final state is intense pain.

Keep the victim of snow blindness in a dark place or bind his eyes with a dark bandage. A cold compress is helpful. Have him rest until recovered. If traveling, blindfold and lead him.

Colored glasses are the surest means of preventing snow blindness. Heavy horn-rimmed Air Force goggles, which are rose tinted, give ample protection with little eye strain or fogging. For blizzard conditions, a leather-lined plastic or metal slit-goggle is useful. Eskimo goggles have the special virtue of not frosting over, but they limit the field of vision. You can make these of wood by burning or cutting out slits

*Improvised goggles.*

large enough to admit a half-dollar. Place one of these over each eye. Keep them on with a cord about the head. You can make glare shields by cutting T-shaped slits in thin pieces of wood or shells. Bind the "lenses" together and keep them on with a cord.

Wear colored glasses (or their equivalent) constantly for daytime operations in snow- or ice-covered regions, and carry spares in case of breakage. When your glasses cloud or frost over, resist the impulse to remove them or to peer around the rims. A thin coat of glycerin on the lenses will partly prevent clouding. If you are without an anti-clouding preparation, keep the glasses on, removing them only occasionally to clean them; have a handkerchief always handy for this purpose.

Blacking your nose and around your eyes, as well as looking at dark objects as you travel, helps somewhat to reduce glare, but remember, these are merely extra precautions, and are not a substitute for dark glasses.

### SUNBURN

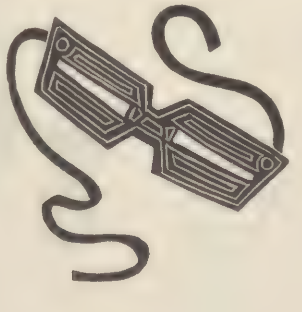
Sunburn is a major source of discomfort in summer operations where there is much snow or ice. It is caused both by the direct rays of the sun and by reflection of light from snow and ice surfaces. Lips and nostrils are especially susceptible. Sun-blistered lips that become infected can produce serious results. Use lanolin cream to soothe the sting of sunburn. The best preventive is the application of a mild opaque ointment such as petroleum jelly or lanolin along the red line of your lips and at the corners of your nostrils. Resist the temptation to remain stripped to the waist longer than a few minutes on a very sunny day. Wear at least a light garment at all times. Remember that it is the combination of direct and reflected sunlight that causes the bad cases of sunburn.

### CARBON MONOXIDE POISONING

Whenever you use a stove, fire, or gasoline heater indoors, there is danger of carbon monoxide poisoning. Many cases have occurred among ground crews working in planes and using gasoline heaters for warmth. Carbon monoxide is a deadly gas and is particularly dangerous because it is odorless. Make sure, therefore, of a steady supply of fresh air in your living and working quarters.

Generally, there are no symptoms. With mild poisoning, you have a headache, dizziness, yawning, weariness, nausea, and ringing in your ears. Later on, your heart begins to flutter or throb. But the gas may hit you without any warning whatever. You may not know that anything is wrong until your knees buckle. When this happens you may not be able to walk or crawl. Unconsciousness follows; then death. Or you may be asphyxiated as you sleep.

In case of carbon monoxide poisoning, get the victim into fresh air at once but keep him warm. In winter, fresh air means merely circulating air that is free from gas; exposure to outdoor cold might cause collapse. If the only fresh air is outdoors, put the patient in a sleeping bag for warmth. Hot water bottles and hot pads are helpful in maintaining body temperature. Keep the patient absolutely quiet and warm for at least a day. *Never exercise a carbon monoxide victim.* This further reduces the precious supply of oxygen in his blood, and increases his demand for it. If a gassed person stops breathing or breathes only in gasps, start artificial respiration immediately. In the latter case, your movements must be carefully synchronized with the victim's gasps. Use pure oxygen and a mask if available. Breathing pure oxygen removes carbon monoxide from the blood faster than does breathing air. The only preventive of carbon monoxide poisoning is proper ventilation.



CHAPTER 9

# RECREATION

One of the most difficult things to get used to is a dull monotonous life. This is true anywhere—in the United States, the South Pacific, or the polar regions. The solution is to keep your mind occupied. This imposes no problem if you are stationed on a large post or near a city or town. Then your life will fall into the familiar pattern. However, if you are stationed on a small post and not near a town, it may require a bit of ingenuity. After a few weeks at such a post, you will probably begin to have some time on your hands. The use of that time is mighty important. Here are a few hints which may help.

## GENERAL

Men who have lived successfully in isolated posts are always systematic in their habits because they have found that when they become careless in their personal habits, they become equally careless in their work, and they gradually get depressed. Set up and follow regular routines. You will feel better both mentally and physically, and your work will progress more efficiently. Depending on your idea of fun, you'll walk, read, or shoot the bull with the boys when you have time off. If there are enough interested people, you can participate in the familiar sports such as football, baseball, hockey, and sometimes even swimming—depending on the season, of course.

Sometimes you might try Arctic variations of the popular sports, such as baseball on skis. Such variations will provide you with a great deal of fun and a lot of laughs.

You may find the polar regions so interesting that you'll want to explore the areas within easy walking distance. Ask one or two of the boys who don't get into your hair to take a hike with you. The walk will do wonders for your disposition and you'll come back feeling a lot better. If you've been doing some tough physical work, you may not feel like walking, so try a visit to the post library.

## ROUGHING IT

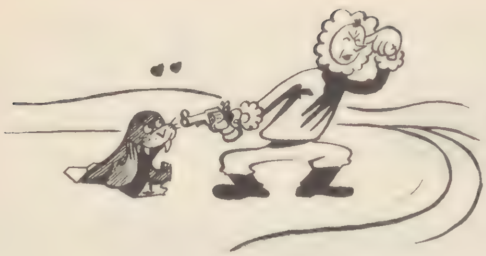
Don't be a *cheechako*—a little bird that comes after the snow is gone and leaves before it comes again, and the name that the Alaskans give a tenderfoot.


In the polar regions, the outdoors offers plenty of opportunity for enjoyment and for gaining useful practical experience. You can never tell when you may have to get along on your own in an emergency. An understanding of the fundamentals of polar living is not only fun to acquire, but it may actually pull you out of a jam some day.

On an occasional weekend you might try a camping trip. You can probably get the necessary gear from Unit Supply. You won't have to go far—a few miles will do. If you plan to take to the trail, study the techniques for living in cold climates. Read the portion of this guide dealing with survival. While this information is intended for emergencies, it will be useful on your hike. Be sure to learn in advance about the "off limits" areas near where you are going; these include most native villages. A word of war ing—stay away from glaciers—they may look challenging, but unless you're an expert, bypass them.

## SNOW SPORTS

If there's enough snow at your post, try skiing. Start first with cross-country stuff and gentle slopes until you get good at it. Snowshoeing is great sport, too. Snowshoes are slower but they're really useful in deep snow, and when you learn to master the awkward things, you've really got something to crow about.



Dog-driving is a great sport. You'll miss the opportunity for a real thrill in your life if there are dogs at your base and you don't try sledging. You can ask the official dog-driver for lessons and learn from him how to harness the animals and how to give the proper commands.

### HUNTING AND FISHING

Take advantage of your stay in the Far North to get in some polar hunting and fishing. There are a variety of animals, birds, and fish to go after. You will find that any of them will give you great sport.

Of course, you had better investigate the local hunting and fishing laws. Note particularly that, contrary to practices in most states in the United States, you do not have the rights of residence in Alaska simply because you are a member of the armed forces. Another point is that you must be assigned to Alaska for one year *immediately before* you make application for a resident license. Therefore, you will probably need a non-residence license for the first year, which will prove more expensive and not allow you as high limits. Even so, you will find that it will pay you well to go in for hunting and fishing.

Most of Alaska, including the Aleutian Chain, offers wide variety of fishing. At Ft. Richardson, for example, you can fish without leaving the post. Fairbanks, to take another example, has abundant streams from which to lure the hungry trout. In some streams on Adak, they say, there are times when the salmon are so numerous that you can catch them at will with a net. Hunting facilities are likewise limitless. Small game, plus moose and bear, offer a wide variety of quarry.


For detailed suggestions on getting game and fish, see Chapter 18.

### EDUCATION

Look into the correspondence courses offered by the United States Armed Forces Institute. Many of our colleges and universities are backing the plan and will recognize the credits accumulated at your polar post. If you don't want to sign up for courses, you can take an Educational Maturity Test. The result processes through the Institute and is issued as a basis for awarding of academic credit. The Institute certainly is worth trying because it will not only help you spend your leisure time but will also enable you to pile up credits towards a degree while you're in the Far North.

### HOBBIES

Pursuit of a hobby will do much to help you enjoy your time, particularly if you have to stay at isolated bases. You can probably pursue any of your hobbies as well in the Far North as in the States. Quite a number of people are photographic enthusiasts. Cameras and film are readily available in PX's and there is a wealth of photogenic scenery, to say nothing of natives and their costumes. Leather working, ivory carving, fly tying, and a variety of other creative hobbies are also quite popular. You will find well equipped hobby shops on all bases.

These are just a few suggestions for a program of leisure. Whether you do any of these things is up to you. Remember that boredom is a kind of disease that may eventually wear you down. You polar experience can either be an agreeable one or the dullest stretch you've ever put in. The way you use your leisure time and adapt yourself to polar conditions can make it one or the other.

PART

3

# MAINTENANCE

# PART 3

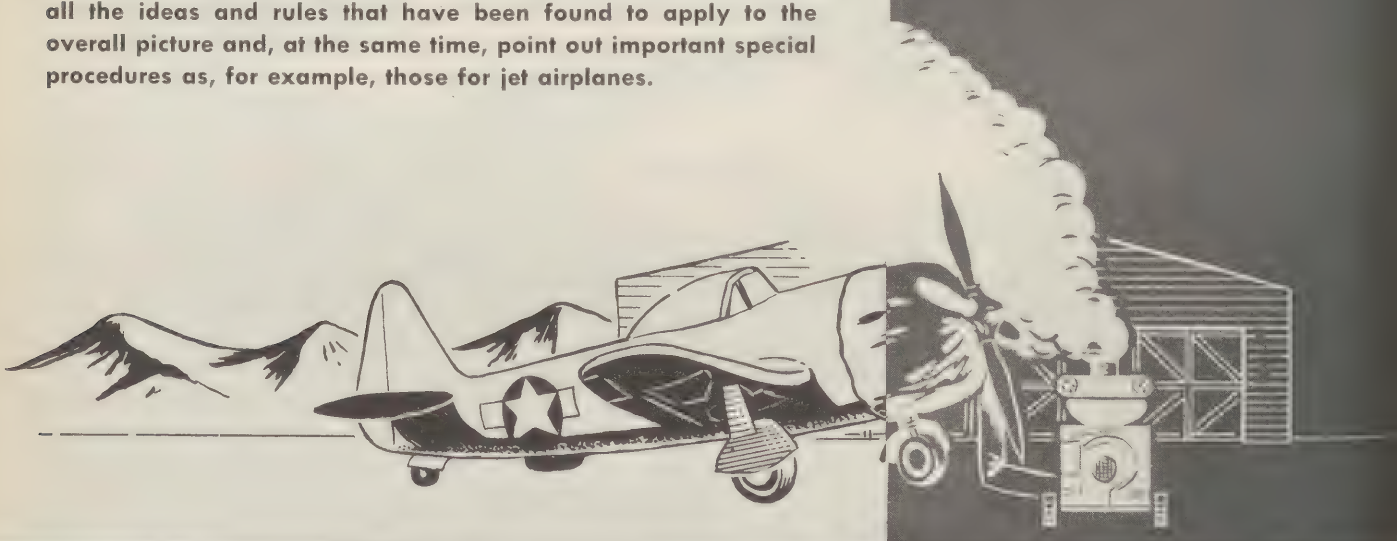
## CONTENTS



There is no question about it — aircraft maintenance in the polar regions is rough. But probably more troubles result from insufficient precautions than from any other cause. You can eliminate these troubles if you follow closely the procedures laid down for cold-weather maintenance and operations. Learn the rules of polar maintenance early — and learn them well. Try to understand the effects of cold. Under extreme conditions of cold, maintenance takes longer and is downright uncomfortable much of the time, but you can do a good job if you set your mind to it.

Aside from normal maintenance, you will be concerned chiefly with preventing and removing ice and snow on airplane surfaces, lubricating moving parts properly for low-temperature operation, diluting the engine oil to help cold-weather starting, and applying heat to the engines, instruments, and accessories when temperatures are extremely low.

This part of the guide deals with the general problems of cold-weather maintenance. It does not explain in detail the maintenance procedures for each type of airplane and each specific weather condition — that you will find in the pertinent Technical Order or local S.O.P. It does, however, attempt to standardize all the ideas and rules that have been found to apply to the overall picture and, at the same time, point out important special procedures as, for example, those for jet airplanes.



CHAPTER 10

# PRE-FLIGHT

Most cold-weather operating difficulties occur on the ground, and what you do before take-off determines to a large extent whether the mission will be a success or a failure. So check methodically for every possible source of trouble *before take-off*.

## COVERS

Wing covers can be removed from small planes by one man, but on large planes, it takes two. First, the men untie the ropes. Then one man stands on a maintenance stand at the wing tip of the airplane and the other man stands at the trailing edge of the wing where it meets the fuselage. The man on the wing tip pulls the cover toward him until he is able to reach it from the ground. During this entire operation, the other man is busy watching the cover to see that it does not foul or tear on any projection. Wing covers should be removed with a steady pull directly in line with the wing. Particular care should be exercised in removing covers having tie-down hooks or blocks which may damage the de-icer boots and control surfaces.

Covers are essential to polar operation. Handle them carefully. Before you fold the covers, shake free any snow present and untangle the ropes. Remember that if wing covers are carried in the plane, the snow on them will melt when the cabin heaters cause the temperature to rise above freezing, and upon landing, the wet covers will freeze and become stiff and unmanageable. The only cure for this is to take the covers into a hangar (if available) and allow them to dry thoroughly. Inspect the wing covers regularly. Repair any tears immediately.

With some old-type covers, there are extra covers on the air-speed tube and the carburetor air intake. Be sure to remove any such covers before take-off. In the case of jet airplanes, be sure also to remove the dust plugs in the air intake ducts and tailpipe.

If the engines are covered, do not remove the engine covers until the pre-heating process is completed. They improve the efficiency of preheating considerably by preventing loss of warm air and entry of cold air. In practice, however, engine covers are frequently not installed, for it is felt that the many difficulties encountered in using them more than offset the advantages gained. Attempts are therefore being made to develop a suitable nose section shield which will

accomplish the same purpose as an engine cover but will be much easier to handle. This shield, it is planned, will be placed between the propeller and the nacelle, will be hinged so it can be fitted around the propeller shaft, and will contain flapped openings to permit the insertion of heater ducts.

### PRE-HEATING

Every effort is being made to permit cold weather starting of engines. Experiments are being conducted with special fuels and with high pressure priming. However, until satisfactory methods are developed, you will need to apply external heat to the engine before attempting to start it. If the proper oil dilution procedure was used at shut-down, apply heat when outside air temperatures are below 0° F. If oil dilution was not used, heat will be required if the temperature is below 34° F. Remember that these temperatures are only approximations. You may start the engine at temperatures as low as 18° F below these, depending on the type of engine installation and on your experience and technique.

Experimentation is now proceeding for the purpose of developing new high-output heaters for rapid and efficient pre-heating. At present, the ground heater in general use at Air Force bases in the polar regions is the type F-1A (modified from the F-1 in accordance with T. O. 19-60-20 to increase the output of the burner). This ground heater is of major importance in cold weather operations, having a capacity of 250,000 BTU per hour. Be very careful, therefore, to follow the operating instructions printed on it. For other instructions, see T. O. 19-60-5. In sub-zero temperatures, do not attempt to start the heater engine until you have pre-heated the heater engine, crankcase, and fuel blower to insure proper lubrication, as shown in T. O. 19-60-5.

The type F-2 hand-operated heater is valuable for quick warming of type F-1A heaters and other small mechanisms. It has an output of 20,000 BTU per hour at 60 rpm. At −20° F or below, it is best to use only 100-octane aviation gasoline in this heater.

**WARNING**

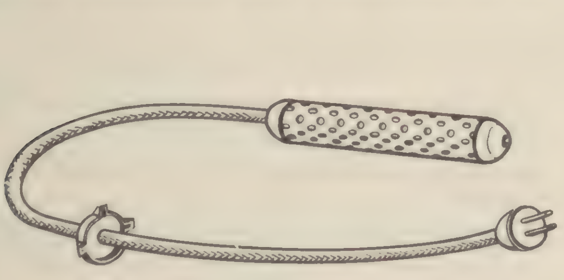
The exhaust gases discharged from the F-2 heater unit reach temperatures as high as 1000° F. Do not use it to heat any equipment which will be damaged by this temperature. Never use the hand-operated heater to heat shelters or occupied enclosures, as air delivered by this heater is NOT free from carbon monoxide.

Apply heat to the power section and the accessory section until the oil will flow from the "Y" drain and the propeller can be pulled through with comparative ease.

*Pre-heating Fighter Plane.*

*Using F-2 Hand Heater.*

Standard engine covers are provided with sleeves for attaching heater hoses at the strategic points. Should you have no engine covers, you can still heat the engines by properly placing the heater ducts. The F-1A heater is equipped with two 12-inch ducts or transition plates that accommodate 6-inch ducts. Don't use the 6-inch ducts on the type F-1A heater at temperatures below $-20°$ F. If you use the 6-inch ducts, place one on the nose section, one on the accessory section, and one on the oil cooler. When you use the 12-inch ducts, place one on the nose section and place the other alternately on the accessory section and the oil cooler. (It is not necessary to heat the oil coolers on airplanes equipped with surge protection and thermostatically controlled oil flow through the coolers. These oil coolers are self-thawing after the engine starts.)

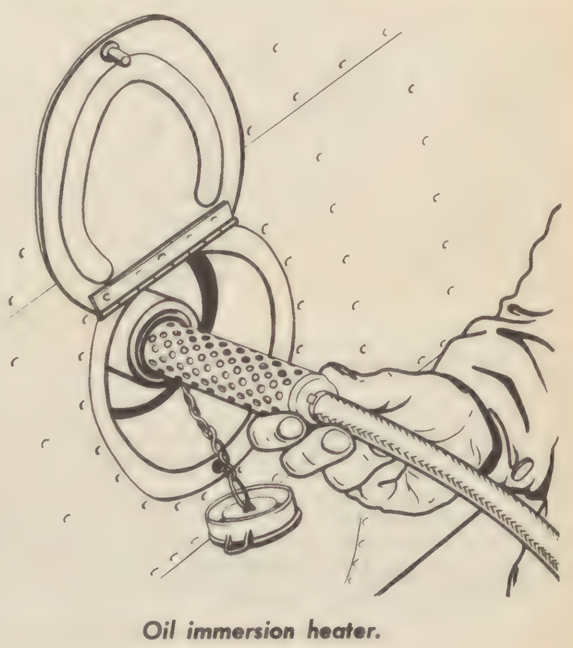


Heat at the power section helps in the vaporization of the fuel and increases crankability; at the accessory section, it de-congeals the oil. If you can't heat the entire engine effectively, concentrate on the rear accessory section and give second priority to the nose gearing and propeller hub. Apply heat particularly to the oil "Y" drain valve, the oil lines, and the oil tank sump. If exposed for long periods at extremely low temperatures, oil congeals in the lines even with dilution.

Heat the starter to free it from the load of congealed oil and contracted metals. Apply heat also to the part of the airplane containing the instruments. However, don't get the blast too close to the instruments as it might crack the glass, boil the fluid in the line, and rupture the diaphragms. Heating the cockpit to defrost the windshield is also a good idea.

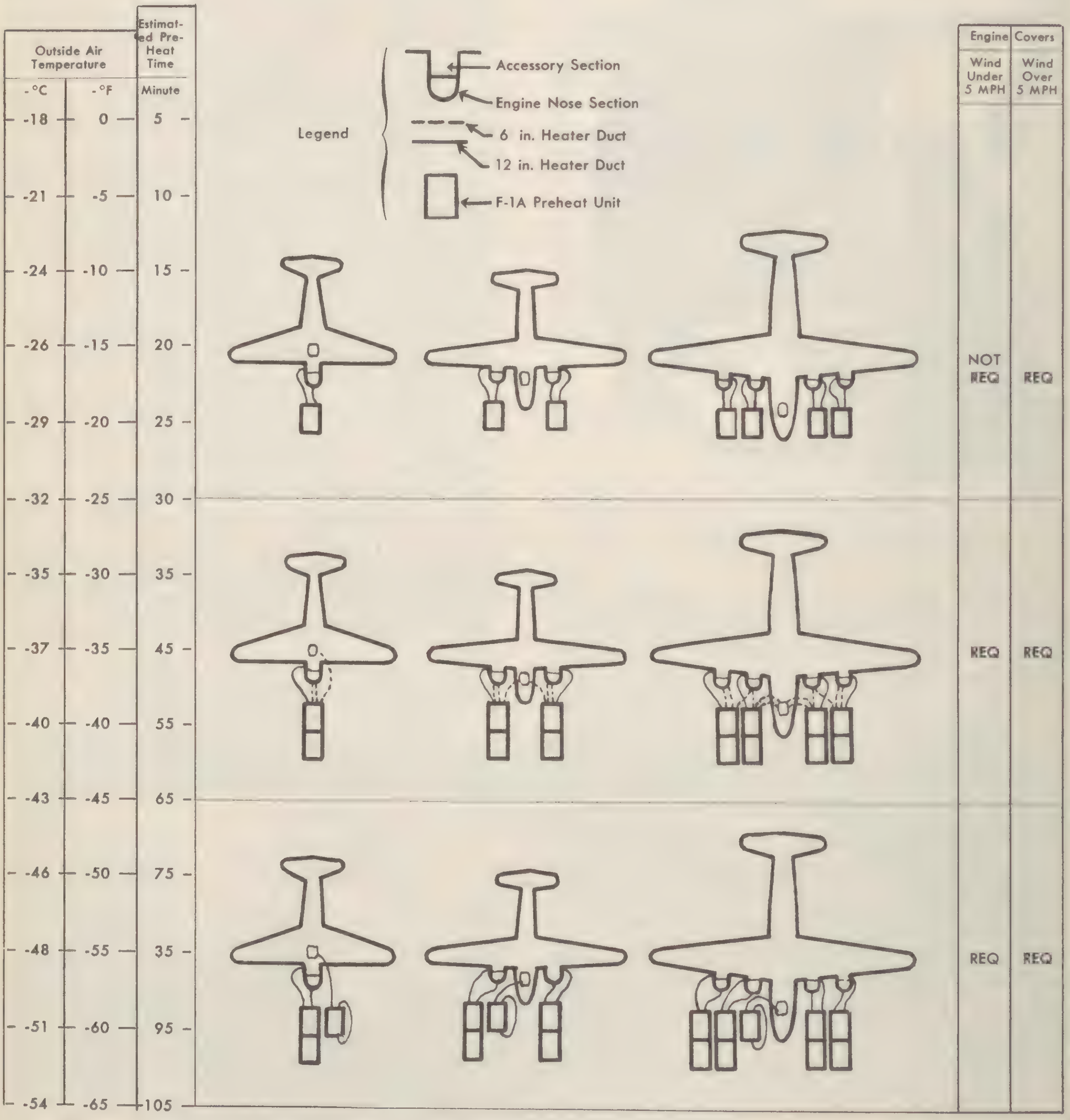
Check the temperature of the air at the discharge end of the heater duct. Do not permit air that is above 250° F to blast against ignition harness, flexible hose, self-sealing tanks, or other rubberized or fabric materials. Do not apply heat directly to oil tanks having self-sealing liners. Because of the insulating qualities of such tanks, they require several days of above-freezing temperatures to loosen oil congealed in them.

Incidentally, immersion heaters will not help in starting an engine or in supplying fluid oil to the oil lines. Immersion heaters are of value only in keeping fluid oil in the tank from con-



*Oil immersion heater.*

## GROUND HEATER ARRANGEMENT FOR ENGINE PREHEAT




1. If proper oil dilution was used at shut-down the chart indicates the estimated preheat time required to preheat engine & airplane.

2. Maintain heater duct discharge temperature between 180° & 250°F. Use additional heaters if necessaryto obtain temperature range. Station heaters and ducts in groups when possible to shield each other and to utilize heat losses of adjacent heaters. Cover heater groups with tarpaulin or shelter if available to minimize heat losses. Warning — be careful to preclude fire hazard.

3. Check duct discharge temperature with Weston Type 226L009 Thermometer Stock No. 7800-844000 or equivalent.

4. On airplanes in which cabin or cockpit heating systems are operable on the ground, you will not need the F-1A units indicated for cabin or cockpit heating.

5. To check crankability — pull propeller through by hand and check to assure oil flow at "Y" drain before stopping preheat and final removal of heater ducts.

gealing. If the oil has already congealed, the immersion heater will make fluid only the oil next to it, but will not help the rest of the system. In fact, you will probably burn out the heater if you use it for this purpose.

The time required to pre-heat the engine and accessories for starting depends on the outside air temperature, the amount of metal to be heated, the size of the heater, the movement of the outside air, the efficiency of the covers, and the amount of oil dilution before the previous shutdown. For example, a properly diluted R-3350 type engine will require at least 35 minutes of heating with an F-1A heater at an outside air temperature of −30° F. Larger engines or improper dilutions may increase the pre-heating period to two or more hours at extremely low air temperatures. Never consider pre-heating adequate until fluid oil will flow from the "Y" drain and the propellers can be pulled through with comparative ease.

As a general guide for the number of heaters you will need for various types of airplanes at various temperatures, and for the recommended arrangement of these heaters, see the accompanying chart. Note that frequently the F-1A heaters are put in series to increase the temperature of the air at the discharge ends of the heater ducts. With the contemplated new modifications of the F-1A heaters, however, it will be unnecessary, even dangerous, to put the heaters in series, for the newly-modified F-1A heaters will be approximately 60% more efficient and their discharge temperatures proportionately higher.

JET FIGHTERS. No pre-heating is required for the jet power plant itself. However, at low temperatures (below −15° F), it is important to pre-heat the canopy, the cockpit, the oil system, and the elevator trim tabs.

Without pre-heating, you will experience considerable difficulty in opening, closing, and locking the canopy properly at temperatures below −15° F. Failure to pre-heat also causes the oil pressure to rise beyond the red-line limit of 50 psi when the ambient temperature is below −25° F. Although, in various tests, this has caused no apparent damage, it is possible that over a period of time damage will take place. Therefore, it is helpful to pre-heat the oil system at low temperatures. Aside from the actual prevention of damage, this will relieve pilots who may become concerned by oil pressure readings beyond the red line.

Be particularly sure that the windshield is clear when you take off. If it is not, the ice or frost will stay on for the rest of the flight, for the cockpit defroster will not melt ice on the outside.

At temperatures of −15° F and lower, elevator trim tabs may not operate for as long as 5 minutes after take-off because of the freezing of the drive shaft. Moreover, the trim tabs may not be at zero when the indicator is at zero, and at the high speeds of jet flights they may cause the pilot to over-control. Pre-heating is therefore essential.

## SNOW, ICE AND FROST

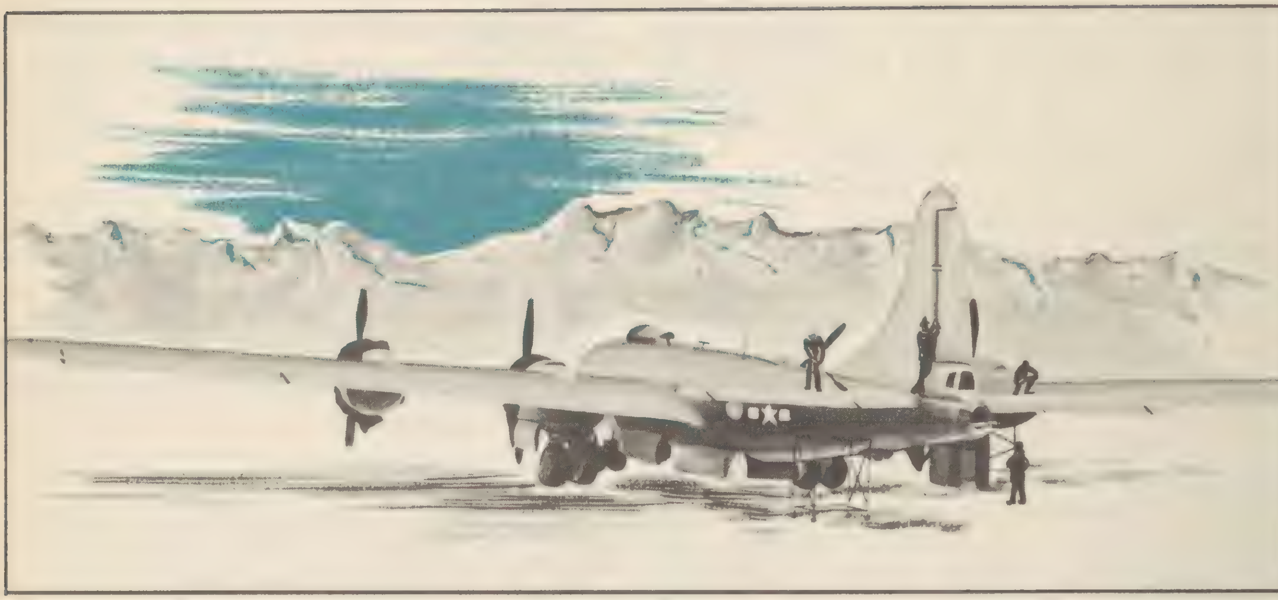
Never take off with snow, ice, or frost on the wings. Even loose snow may not blow off, and only a thin layer is necessary to cause loss of lift and very treacherous stalling characteristics.

When airplanes are dispersed in the open overnight, hoarfrost will usually form just as the sun is rising. No matter how thin it may appear, always remove it, particularly near the wing tips. The simplest method is to sweep the surface with a stiff broom, preferably one with a long handle.

Brush off snow with a stiff broom. Lightly blown snow may accumulate in the wings and fuselage wherever openings remain uncovered. Look for such accumulations and remove them to prevent take-off with an overload of drifted snow.

To remove ice, apply sufficient heat to loosen the ice particles and remove them with a hard brush. Alcohol and other sprays tried for this purpose have proved unsatisfactory. When removing ice with heat, don't melt the ice completely, as the water may get into control-surface bearings and freeze. The best way to remove ice on propeller devices and blades is by direct application of heat. The same applies for shock struts.

When there are sharp changes from moderate to extreme cold, condensation will cause ice to form inside the wings and fuselage as well as outside. Inspect all controls and mechanisms carefully to insure their freedom from ice. Removing this ice is difficult, and, generally, you can accomplish it only by applying heat. Chipping frequently results in damage to the airplane. Never use hot water, either, as it will freeze and aggravate the difficulty.



*Removing Ice and Snow.*

Remove ice and snow from the landing gear to prevent jamming or hindering the retraction of wheels and to permit the proper operation of locking devices. Covers around the landing gear and application of heat from an F-2 heater can help considerably in this operation. Loose snow also tends to blow into the wheel wells on the take-off and then freeze on retraction so that it may be difficult or impossible to lower the landing gear. Apply hydraulic fluid liberally to permit the ice to break off when power is applied to the hydraulic jacks.

Bomb-bay doors and flap-operating gear may also lock through accumulation of ice or frozen snow. Treat them in the same manner as the landing gear. Treat similarly the parts of pneumatic firing gear which are next to the point at which the compressed air is discharged.

Remove snow packed in the carburetor intake. Remove carburetor screens for snow operations. Clean snow and ice off the antennas before take-off.

When the engines or cabins are heated, the snow on top of the wings often melts and runs into the control-hinge crevices and solidifies. Inspect all exposed hinges on flaps, elevators, ailerons, rudders, trim tabs, and bomb-bay doors. Remove any ice you find there.

Operate all ailerons, elevators, rudders, and trim tabs through several complete cycles, noting the resistance. If resistance is excessive, investigate. Check the controls for operation and also to loosen the grease in the bearings. Trim tabs are just as important for safe operation of the plane as the primary controls. Some of the trim-tab mechanisms incorporate a gear box in their systems, and these gear boxes are filled with grease. Make sure they are not frozen.

Check the turrets before take-off and operate them through the full range of traverse, elevation, and depression in order to remove congealing fluid from remote parts of the mechanism and to maintain the temperature of the working parts. This will prevent sluggish operation and, in extreme instances, the sticking of the turret. Always use the external power supply for ground checks.

## TIRES

If your tires have become frozen to the surface, free them by the use of ground heaters, a process which may require considerable time. In an emergency, you may partially release the tires by inflating them to 1½ times normal pressure. Before doing so, however, check for wheel cracks or breaks in the tires. See also that no personnel are broadside to the wheel during tire inflation. If you do over-inflate the tires to release them, be sure not to apply heat also, as this further increases tire pressure. If the tires are released as a result of the increased pressure—and this may require as much as an hour because of the slow action of the tires in response to increased tire pressure—immediately reduce the pressure to normal.

Another tire difficulty encountered at low temperatures is the prevalence of flat spots after parking. If the flat spots are not too large, normal towing of the airplane may roll them out. However, should the tires have a tendency to slide instead of roll when the airplane is being towed, apply heat from a ground heater until it is possible to roll out the flatness. This may take several hours.

### SHOCK STRUTS AND ACTUATING CYLINDERS

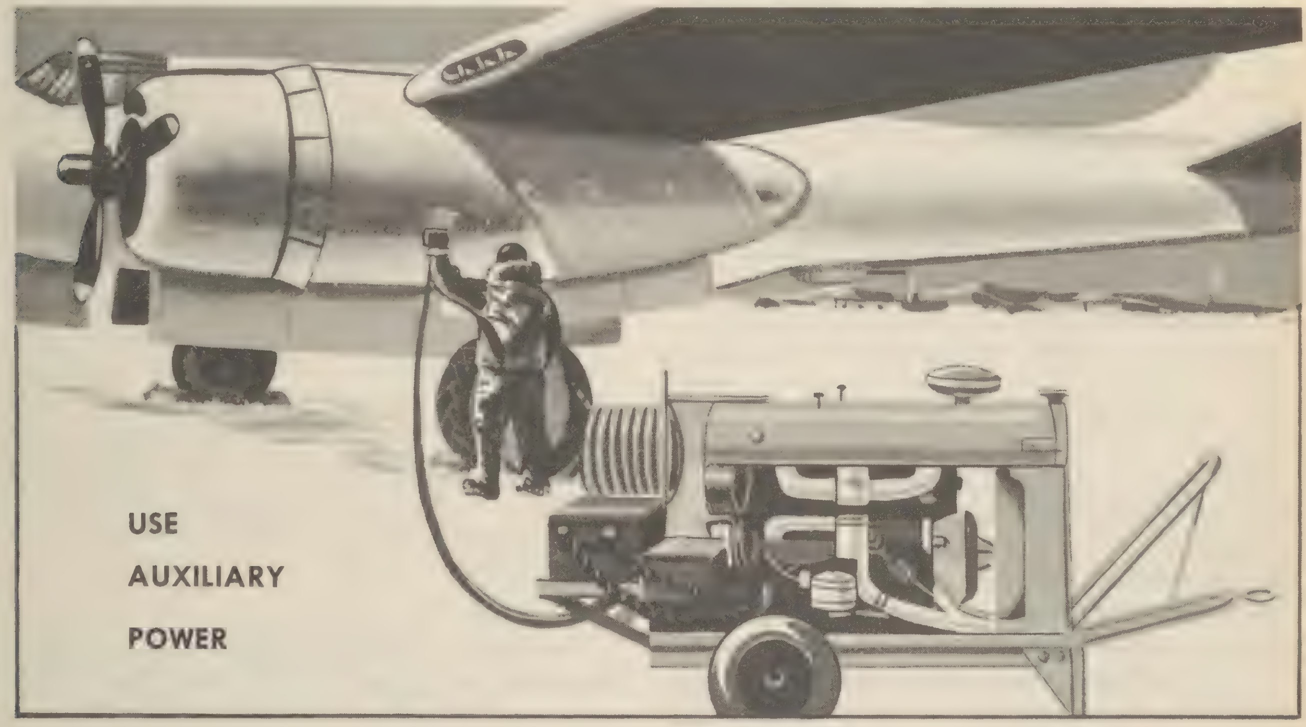
Wipe the shock-strut piston tubes clear of all snow, ice, or dirt with a rag soaked in the hydraulic fluid used in the strut. If you find hard dirt or grit and have difficulty in cleaning, use kerosene as a solvent to remove the dirt, then lubricate the piston again with the hydraulic fluid used in the strut system. Repeat this procedure upon landing. Shock-absorber packings are quickly cut and damaged by ice and grit, especially at extremely low temperatures when they have lost much of their resilience. Refer to T. O.'s 03-25E-1 and -2 and 03-25F-1.

Clean all hydraulic actuating cylinder piston rods which are in the normally extended position, particularly piston rods which are exposed to the accumulation of foreign matter from the propeller blast or wheel action. Clean the piston rods as you did the shock struts. See the applicable technical order for your type of plane.

Examine the shock struts carefully for hydraulic leaks and proper inflation. Check the instructions on the name-plate for the proper distance from the lower end of the cylinder to the inflation mark on the piston. Also look for fluid in the snow. This is evidence of leakage. Note that the packing glands on struts and actuating cylinders equipped with "O" ring packings are non-adjustable. Instructions for adjustment of "V" ring packings are contained in T. O. 03-30-4.

### AUXILIARY POWER

All Air Force airplanes are equipped with an external plug-in for external power carts. When operating in cold weather, make it an unalterable never-to-be-forgotten rule to use an external power source for starting and for running the engine or operating electrical equipment on the ground. If your airplane does not carry an auxiliary power plant as part of its regular equipment, you shouldn't have too much trouble in finding a C-13A generator cart at any air Force station. Get one of these carts if you have to walk a mile for it yourself, and use it even if you have to spend a large part of your day in repairing it. The chances are you will neither have to repair or even start it yourself, but no matter what you have to do, *use the external power source*. The chances of starting without an external power source are remote and the chances of damaging the battery are great.



*Thaw "Y" Drain.*

The C-13A generator cart cannot supply sufficient power for jet starts, which may require as much as 15 KW of power. For jet starts, therefore, you will have to use a dual C-13A cart or its equivalent. This cart is of local fabrication and consists of two C-13A's hooked in parallel with six D-6A batteries across the line.

## DRAINS AND VENTS

Check the "Y" drain and oil tank sump for fluid oil immediately before starting the engines. Do not attempt to start the engine if you can't obtain oil flow from the "Y" drain. If no oil comes out, the chances are that the drains are clogged with ice or congealed oil. Apply heat to thaw them. Be sure to lock the drain immediately after the water is drained or as soon as oil flow occurs.

During extremely cold weather, condensation of water in oil tanks requires frequent draining of the sumps. Check for flow from the fuel-tank sumps. If there is none, apply heat and drain the frozen condensate. Inspect the tank vents and crank-case breathers to make sure that they are free from ice and snow. Frozen condensate will cause stoppage of tank vents and subsequent collapse of fuel tanks. Frozen crankcase breathers may cause the loss of an engine while in flight.

Check the oil-dilution valve to make sure that it is in the closed position and fully seated.

## STARTING THE ENGINE

Remove the engine covers, the ground heaters, and the oil immersion heater.

Pull the propeller through four or five complete revolutions by hand before engaging the starter. If you can't pull the propeller through with comparative ease, apply more heat to the power section.

Prime the engine. In extremely cold weather, considerable priming is necessary to assure successful engine starts. Avoid priming except just before and after the engine is turning. If you prime prematurely, the gasoline will not vaporize but will run down into the lower cylinders and will result in bent connecting rods and cracked cylinder heads when the piston contacts the cylinder full of fluid gasoline. With a hand primer, give it a light priming before engaging the starter and then, while the engine is being turned over, operate the primer with short, sharp strokes until regularity of firing results. You may continue priming for some time after starting to maintain smooth engine operation.

**WARNING**

Overpriming is dangerous. It results in fires, scuffed cylinders, and engine failures. Be cautious when priming.

Start in the usual manner. (Consult T.O. 02-1-29).

Use auxiliary power for starting. Do not make the starter crank the engine continuously for a period in excess of one minute without again going through the cycle of first disengaging the starter from the engine and energizing the flywheel. On airplanes with direct-cranking starters, the cranking cycle should consist of alternate 1-minute cranking periods and 3-minute rest periods. This will prevent starter overheating and allow the battery to recuperate. If the engine does not start after the third or fourth attempt, investigate and find out why, rather than use up all the electrical energy in the batteries. In a number of cases, when the engine does not start readily in sub-zero temperatures, you will find that the spark plugs have become frosted. If this has happened, replace the frosted spark plugs or apply additional preheat or both.

### Jet Engines

Do not attempt engine starts with JP fuel at temperatures below $-10°$ F unless it is an emergency and gasoline starting facilities are not

available. JP fuel starts at temperatures below −10° F result in excessive tailpipe temperatures and cause engine damage. Below −30° F, you will probably not be able to start at all with JP fuel. If you do have to attempt a JP fuel start at low temperatures, you will get better results by first obtaining maximum fuel pressure and cranking speed, opening the throttle rapidly to a maximum position until ignition occurs, and then retarding the throttle *immediately* to a near closed position.

Gasoline starts are much more effective, and gasoline starting facilities should be incorporated in all jet airplanes used in the polar region. Make your gasoline starts as per instructions accompanying airplanes modified for gasoline starting. *Be sure, however, to switch back to JP fuel before take-off.*

## OIL PRESSURE

In starting an engine, make a normal start without regard to the oil dilution system. After starting, watch the oil pressure. Too high an oil pressure or an oil pressure that fluctuates and falls back when the engine rpm is increased indicates a heavy, viscous oil. This may be due to application of insufficient pre-heat, insufficient dilution after the last flight, or both. On Pratt and Whitney engines, the oil pressure relief valve is thermostatically controlled to give high pressure until oil temperatures of approximately 40° C are obtained. Oil pressures as high as 200 pounds per square inch are common on these engines. Do not be alarmed by such pressure.

On jet airplanes, don't be alarmed by oil pressure readings slightly beyond the red line if you have not pre-heated the oil system.

**WARNING**

If there is no oil pressure after 30 seconds of operation, *shut the engine down immediately and investigate.*

If there is frozen condensate or congealed oil in the "Y" drain, apply heat to the drain. If there is failure of the oil-pressure gage due to congealed oil in the lines or lack of transmitter fluid, service the gage lines according to T.O.'s 05-70-4 and 05-70-6, and apply heat.

If oil pressure drops after a few minutes of ground operation, check for:

Failure of the pressure gage.

Blown lines or oil coolers.

Congealed oil or ice in the "Y" drain.

Water in the oil tank sump drain. (If no oil flows, apply heat and drain the water when the heat has thawed the ice.)

Foreign material in the oil strainer which might indicate that engine failure is cause of low pressure.

If the oil tank sump or "Y" drain is frozen or if the oil lines or coolers are blown, the pilot did not follow shut-down instructions properly. Take the necessary corrective measures.

## COWL FLAPS

Adjust the cowl flaps in such a way that the cylinder head temperature is equal to that for normal flight conditions. Naturally, the cowl flap opening required for this will vary with the type of engine.

## ELECTRICAL EQUIPMENT

Keep all non-essential electrical units off until the generators cut in. See T. O. 01-1-61 on the use and conservation of electrical power. Cold batteries hold very little charge and are soon depleted when current from the airplane generators or auxiliary power sources is not available.

## CARBURETOR AIR HEAT

Always keep the carburetor heat control in full cold position while starting in order to eliminate heater valve damage due to backfire.

In cold weather, engine operation immediately after starting is frequently rough, with backfiring and after-firing. This is due principally to poor vaporization of fuel with consequent lean mixtures and poor combustion, too low cylinder head temperatures, and frosted spark plugs. Use carburetor heat as soon as the engine is firing regularly to increase the fuel-air ratio and improve vaporization and combustion.

## OIL SCAVENGING

Normal warm-up procedures will usually evaporate sufficient gasoline from the oil to eliminate any difficulty with scavenging. Engines, such as in-line engines (V-1710 and V-1650), which have unsatisfactory scavenging systems may have to be ground run before take-off to boil the gasoline out of the diluted engine oil in order to avoid loss of engine oil in flight. If feasible, ground run engines with an inadequate or critical engine-oil scavenging or engine-breathing arrangement at approximately cruising rpm for five or ten minutes after warm-up. Watch engine temperatures to avoid over-heating. Some air-

planes with V-1710 engines, however, such as the F-82E, are provided with a centrifuge and revised breathing system which prevents loss of oil. Such airplanes do not have to be ground run to boil the gasoline out of the diluted engine oil.

If oil discharge occurs under cold conditions, the best way to stop it is to reduce power and rpm immediately. If you notice oil discharge during take-off, reduce rpm as quickly as practicable and run at medium power for ten minutes.

After several days of layover, during which the engine has been started and diluted several times, ground run the engine for at least half an hour at normal temperatures before take-off. This will tend to eliminate any excess dilution which might otherwise cause oil discharge through the breathers or loss in oil pressure during high power take-off or operation. Also check the oil level; it may have fallen considerably due to the evaporation of gasoline.

### PROPELLER CHECK

After the engine-oil temperature and pressure are up to normal, operate the propeller control so that a drop of 400 rpm is obtained. When this drop is observed, pull out the switch and allow the rpm to return to normal. Repeat this procedure three times. This action insures proper oil circulation. At extremely low temperatures (below $-30°$ F), ground run-up at full-power results in a slightly lower rpm than at moderate temperatures. Do not adjust the propeller governor settings to get normal rpm under these conditions, as such action would cause the propeller to overspeed during take-off.

If you have a full-feathering hydromatic propeller, check the feathering system. You should get a 400-rpm drop by depressing the feathering button. In case the rpm drop is very slow or sluggish, repeat the check until operation is satisfactory. Do not depress the feathering button for more than twenty seconds at any one time since this will overheat the feathering motor and shorten its life.

See the applicable technical order for your particular type of propeller for other information on its inspection, maintenance and operation.

CHAPTER 11

# POST FLIGHT

## OIL DILUTION

If you expect a cold-weather start, you will have to dilute the oil in the hopper and the entire circulating oil system with fuel in order to insure fluid oil for starting. Use the following procedures:

1. Before stopping the engines, set the throttle to about 1,000 to 1,200 rpm.

2. Maintain the oil temperature below 50° C and the oil pressure above 15 pounds per square inch. If the engine-oil temperature is too high, stop the engine. After the oil has cooled to below 40° C, re-start the engine and proceed with the oil dilution. Because of fuel evaporation, diluting the oil when its temperature is above 50° C is not effective.

3. Hold the oil dilution switch in the ON position for the period of time indicated in the applicable technical order. You may deviate from these periods as shown necessary by experience with the particular conditions under which you operate. In general, dilution time is 3 minutes for temperatures between 40° and 10° F, 6 minutes for 10° to −20° F, and 9 minutes for −20° to −50° F. Add one minute of dilution for each additional 9° F below −50° F.

4. Operate the propeller control the last two minutes of the dilution to get a change of 400 rpm. Repeat this cycle three times. If the airplane is equipped with full-feathering propellers, operate the propeller feathering switch the last 2 minutes of the dilution to obtain a 400-rpm drop. Repeat this cycle three times.

With all high-pressure carburetors, approximately one gallon of fuel is added to the oil system each 2 to 2½ minutes. The rise in oil tank level that results is due to the addition of diluent and does not provide oil for engine usage.

To insure proper cold-weather operation of Eclipse turbo-super-charger regulators operating on engine oil during dilution, operate the regulator control repeatedly for the last two minutes of the dilution period. Operate the regulator control from low to high boost with a minimum time period of eight seconds for each cycle of operation. Follow this procedure only on airplanes equipped with an individual turbo-regulator control in the cockpit.

When fifty hours of engine time have elapsed since the last oil dilution was accomplished, use two or more dilutions instead of one. On these occasions, give the engine the full dilution period and, after dilution, shut down the engine and remove and clean the oil pressure screens. This is necessary because the fuel in the oil tends to wash down any accumulated sludge within the engine. After reinstalling the oil screens, start the engine and run it for at least twenty minutes at 1000 to 1200 rpm to evaporate any fuel in the oil. Then drain the oil system and refill it with the proper grade of oil. After this, dilute the engine again for the usual period of time.

At any time when a long dilution period is required and the oil temperature exceeds 50° C, you will have to dilute the oil in two or more short periods in order to maintain oil temperatures below that temperature. On such occasions, stop the engine when the oil temperature reaches 50° C, allow it to cool until the oil temperature is well below 40° C, then re-start it and continue the dilution.

If it is necessary at any time to service the oil tank, divide the oil dilution procedure so that some dilution is accomplished before servicing the oil tank and the remainder is accomplished after the oil tank is serviced.

**WARNING**

It is dangerous to service with undiluted oil, as this heavy oil collects, and may congeal, on the tank bottom and block the oil flow.

After dilution, shut off the engine in the normal manner (unless it is an engine which must be stopped by shutting off the fuel to prevent back-firing). Continue to hold the dilution valve ON until the engine stops.

Whenever the engine has been diluted previously and has not been flown, don't give it a full dilution until after forty-five minutes of operating with oil temperatures above 50° C. If you make a short ground run-up, re-dilute the engines, but reduce the time of dilution to

the point where it bears the same relationship to the dilution time shown in the applicable technical order for your plane as the ground run-up does to one hour. However, never let the dilution period at shut-down be less than thirty seconds.

It is necessary to operate an airplane engine at normal operating temperatures for approximately forty-five minutes to an hour to permit the fuel in the oil supply to evaporate and cause the oil to resume its normal viscosity. Temperatures of 70° C and higher will shorten this time period slightly.

As an example of what the dilution amounts to in percent, here is the percent of dilution by volume of Grade 1100 oil required to provide the same oil viscosity at each of the temperatures given:

| *Air Temperature* | | | | |
|---|---|---|---|---|
| 40° F | 10°F | −20° F | −50° F | −65° F |
| *Percent Dilution* | | | | |
| 0 | 10 | 20 | 30 | 35 |

When it is extremely cold and an airplane layover is necessary, you may increase the dilution procedure as you deem necessary. After several days layover, during which the engine has been started and diluted several times, ground run the engine for at least half an hour at normal temperatures. Also re-service the oil system before take-off and check the oil level which may have fallen considerably as a result of evaporation of gasoline. This will tend to eliminate any excess dilution which might otherwise cause oil discharge through the breathers or loss in oil pressure during high-power take-off or operation.

### SHOCK STRUTS

As soon as possible, clean all dirt, grit, and ice from shock struts and actuating cylinders. You can do this easiest while the piston rods are warm.

### DRAINS

Drain the oil tank sump and Y-drain of condensate before moisture in them freezes. Heat the fuel tank drains and drain them at every 25-hour inspection.

Inspect fuel and oil caps and vents and crankcase breathers, and remove ice. Remove snow, ice, and frost from inside and outside wings and fuselage.

*Clean the shock struts.*

### DRAINAGE OF OIL AND COOLANT

You should never have to drain oil if you follow the proper dilution procedure. All Air Force fields in cold-weather areas are equipped with ground heating equipment and auxiliary power supply. With these two facilities and proper dilution, you can start at any outside air temperature you will encounter. However, with small planes, when you think that external heat will not be available for starting or that dilution cannot be accomplished, drain all oil into clean containers and store the oil in a sheltered location where the temperature will not be lower than freezing. Where warm storage space is not available, put the containers in the best possible place and, when you need the oil, heat it on a stove or other heat source until it is free flowing, and then pour it back into the oil tank just before starting the engine. Heat the oil to 158° to 176° F if possible.

### CHANGE OF FUEL

On jet airplanes, when you anticipate low temperatures (−10° F and below), purge all JP-1 fuel from the fuel system by introducing the gasoline from the special tank into the engine for at least 2 minutes before shutting down, so that the gasoline will be available for starting. Shut down the engine with the gasoline system in operation.

## OIL IMMERSION HEATERS

Oil immersion heaters are valuable in preventing the fluid oil in the tank from congealing, but their use in no way eliminates the necessity for diluting the oil. You generally don't have to run the immersion heater continuously. Two- to four-hour periods of operation with similar off periods are enough to maintain fluid oil in the tank except at extremely low temperatures. See T. O. 03-15-22.

To prevent foreign matter from getting into the tank, wipe the heaters carefully before you use them. Before starting the engine, remove the heater, close the oil tank, wipe off the heater, and hang the assembly in a convenient location.

Oil immersion heaters of the cartridge type have a flexible oil-resistant lead for dropping into the filler neck of the oil tank. These heaters have a perforated shield around the cartridge to prevent their burning the lining of self-sealing oil tanks and have a lock-type cap to keep them near the bottom of the tank and to prevent foreign matter from entering the tank. Because of the large type oil-filler opening in planes such as the B-25, B-26, C-47, and C-54, an adapter is needed to allow the oil heater to be locked in place. These adapters will probably be available.

Two sizes of heaters that operate on a current supply of 115 volts are available: type C-5 with a 250-watt capacity and type C-7 with a 750-watt capacity. The airplane skin near the oil-tank filler neck will be stenciled with the size of oil immersion heater to be used. If not, use 250-watt, 150-volt heaters in *all* self-sealing oil tanks and in metal tanks with a capacity of less than 20 gallons. Use the 750-watt heater in all others.

**WARNING**

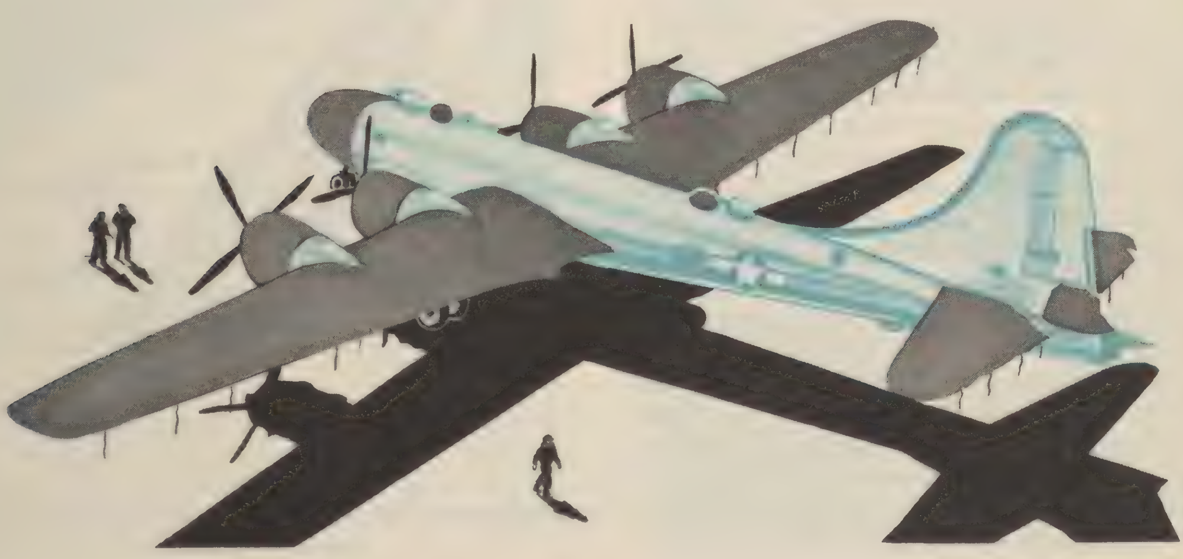
Never use the heater in self-sealing oil tanks without the perforated shield. Do not use more than 115 volts on any of these heaters. Do not use a heater of greater voltage than called for in the stenciled statement on the airplane skin. Be sure the heating element is completely submerged and do not use the heater at free air temperatures above 32° F.

## COVERS

Cover the engines, wings, tail surfaces, windshields, nose, canopy, turrets, and carburetor air scoops. Consult T. O. 03-35-2 for detailed instructions on the use and installation of wing and tail covers, and the stock numbers of the covers for various types of airplanes. Brush off all snow before putting on the covers.

Formerly, there were two types of form-fitting wing and tail covers: a pre-shrunk airplane cloth for regions of extreme cold, and a water-proof material for warmer climates subject to rains followed by freezing temperatures. Covers in present production are of the water-proof type only and are intended for use in all regions. All

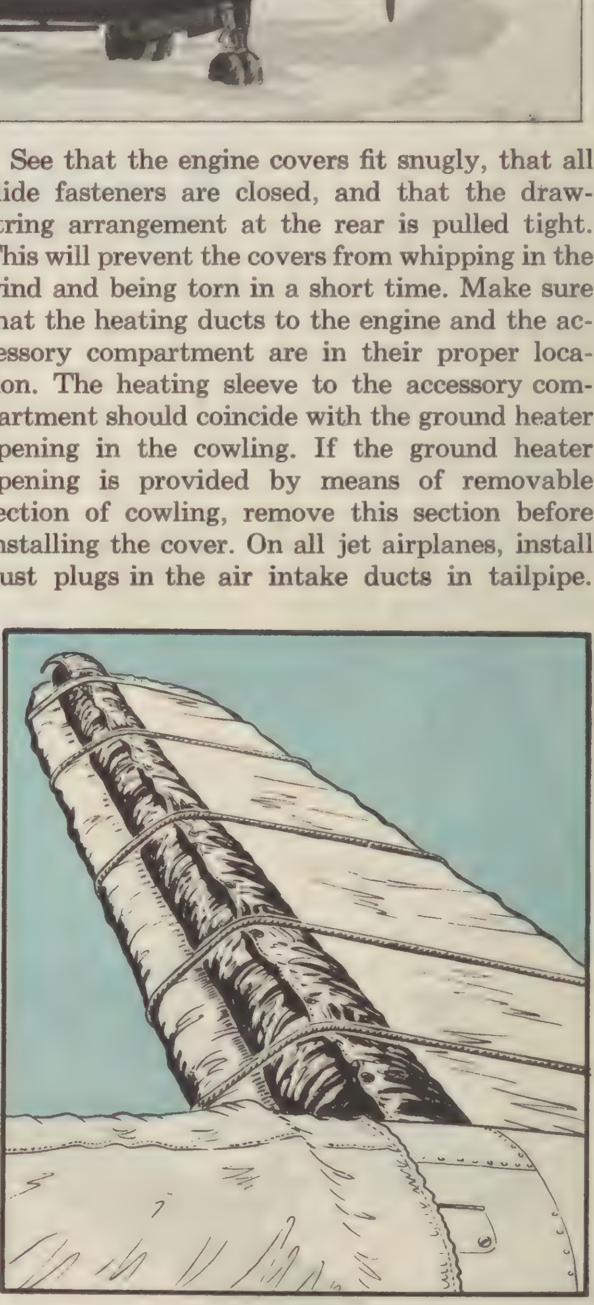
B-29 COVERS



covers are of the quickly detachable type and of such design that you may safely have them on the airplane while the engines are running. These covers prevent the formation of frost on the horizontal surfaces when the airplane is on the ground or taxiing. To accomplish their purpose, covers must be "skin-tight" to prevent frost formation under them and to resist the tearing action of the wind and slipstream.

If all the accumulated snow was removed from the wing covers and they were folded properly when removed, (see T. O. 03-35-2), replacing them is a fairly easy task. On fighter-type airplanes, covers can be installed by one man if there is no wind. However, on large bombers it takes three or four men to install covers. The folded wing covers are placed on the top of the wing, preferably near the tip. One man stands on the wing and the other two or three on the ground. The man on top of the wing installs the wing-tip pocket and adjusts it. Then all the men unroll the cover back to the fuselage and spread it evenly over the wings. Because wing covers are tailored for each airplane, you can easily tell whether or not the wing covers are properly installed. Perform most of the installation of wing covers on your hands and knees, or damage will result to the wing surface. Be particularly careful when working near the wing tips, as the wing structure was not designed to withstand much weight or pressure. One good rule to remember is to be astride the main spar as much as possible. De-icer boots are often damaged when inexperienced personnel attempt to cover a wing—use caution on the leading edge. Be careful also not to damage the control surfaces on the trailing edge.

See that the engine covers fit snugly, that all slide fasteners are closed, and that the draw-string arrangement at the rear is pulled tight. This will prevent the covers from whipping in the wind and being torn in a short time. Make sure that the heating ducts to the engine and the accessory compartment are in their proper location. The heating sleeve to the accessory compartment should coincide with the ground heater opening in the cowling. If the ground heater opening is provided by means of removable section of cowling, remove this section before installing the cover. On all jet airplanes, install dust plugs in the air intake ducts in tailpipe.

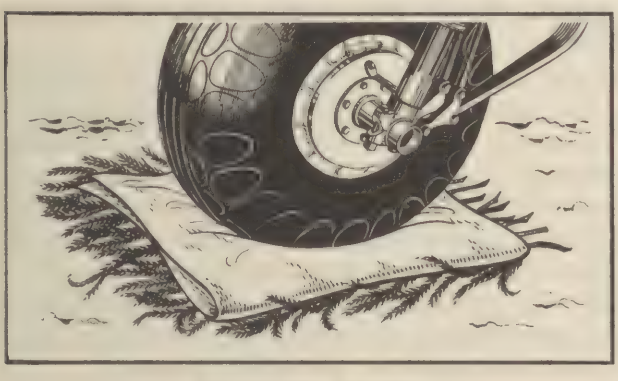


*Tarpaulin Spoilers.*

## PARKING AND MOORING

When you park on ice, when you have gone through slush, or when the temperature alternates between freezing and thawing temperatures, place a layer of double sheets of paper, fabric, grass, straw, green boughs, or other insulating material under the wheels to prevent their freezing to the surface. Otherwise, large chunks of rubber may be torn from the tires when the airplane is again moved.

Because of the freakish winds that develop in some parts of the Far North, such as the Aleutians or Greenland, planes there must be tied down at all times. If there are no permanent mooring bits, use the mooring arrows in the airplane mooring kit. Another good type of mooring is the "deadman" type. Dig a hole in the ground, or in the snow if it is well packed, attach a log, heavy branch, or other object of similar size and weight to the mooring line, place this "deadman" at the bottom of the hole, and pack the dirt or snow you dug out of the hole firmly on top of the "deadman." When the ground is frozen too solidly to use the mooring arrows or "deadman" mooring, fill sacks, boxes,



*Prevent tire freezing.*

or other containers with sand and gravel and use them as anchorage points. Trees and boulders are also good anchorage points. Use spoilers on the wings. Rolled-up tarpaulins tied to the top of the wings make good spoilers. Keep the mooring lines loose, for they shrink when they become wet and may pull loose or damage the plane.

To prevent damage to the nose gear assembly due to high loads and shock loads resulting from towing airplanes with tires frozen or in deep snow, use main gear tow bars during low temperature conditions.

## IMPROVISED MOORING

While some maintenance personnel are of the opinion that parking airplanes in a hangar is advantageous at very low temperatures, this practice is generally out of the question, for sufficient hangar space is not available, nor is it likely that it will ever be available. Moreover, hangar parking is not as advantageous as might be believed at first. Rapid and extreme changes in temperature cause differential expansion and contraction which result in fuel leaks, cracked canopies and windshields, and other difficulties. Cold airplanes wheeled into a warm hangar "sweat" profusely all over and thus become subject to various moisture problems. In addition, struts often go down when airplanes are wheeled out of the hangar, and time is consumed pumping them up again. In general, therefore, you must plan on parking airplanes outside, unless you must accomplish such maintenance as cannot be done outdoors.

When you park the airplane outside for the night, leave either the emergency escape hatch or some other opening partly open. This will permit the circulation of air inside the cabin or cockpit, and so prevent the frosting up of the windows, which is certain to occur in cold weather if no circulation of air is provided. Take precautions to prevent blowing snow from entering the opening.

## NOSE HANGARS

Portable nose hangars help considerably in the maintenance of tactical airplanes in cold weather. They may range from small, improvised structures to large and elaborate installations, built on skids or permanently located. The permanent hangars are floored, solid-framed, insulated and heated, fitted up with tool benches and storage room, with one side composed of canvas openings equipped with draw strings, through which the nose and engine nacelles protrude. This arrangement makes a very fine hangar for all normal maintenance. Types are available to accommodate one-, two-, or four-engined airplanes.

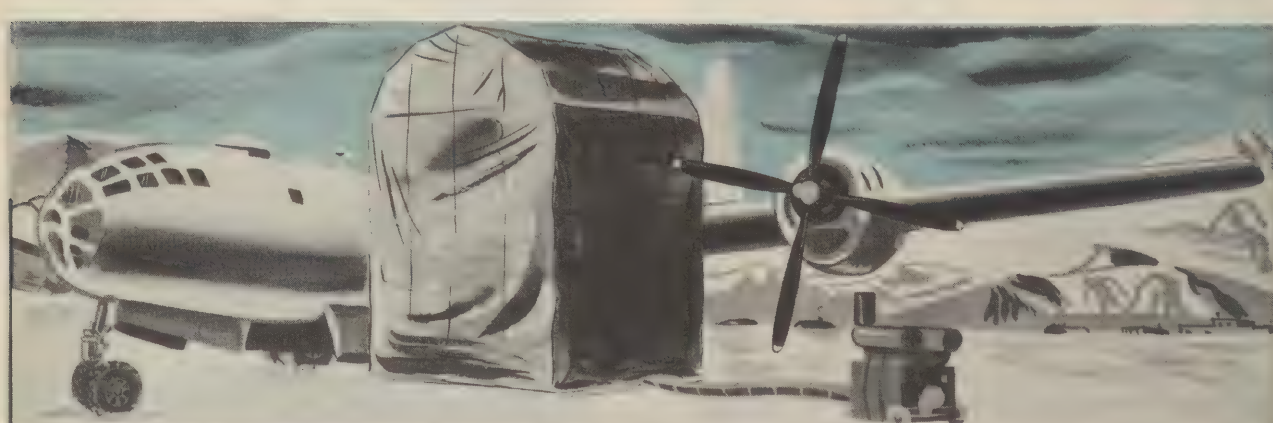
At most fields, portable nose hangars (field maintenance shelters) are available. When used in conjunction with ground heaters, these are good substitutes for a hangar. In case there are no nose hangars available, erect makeshift shelters of tarpaulins. Where no mooring facilities are available, freeze down the guy ropes of the portable or makeshift hangars to keep them in place. Get lighting equipment and an electric generating source; although plastic windows are sometimes provided, it is usually too dark to work in the shelter.

## AIRPLANE LAYOVER

When an airplane layover is necessary in extremely cold weather, follow the proper dilution procedures.

If adequate heating facilities will not be available for engine starting and the airplane must be kept on the alert, you may have to run the engine periodically throughout the layover period. Keep the cylinder-head temperature above 0° C.

For long layovers, (several days), remove the battery and store it in a warm place. At temperatures below $-20°$ F, remove the battery from airplanes not equipped with auxiliary power units if the layover exceeds 4 hours. Drain the oil and cooling systems if it seems desirable. If, during the layover, the temperature rises above 32° F, immediately drain all fuel system and oil tank drains of condensate, before the temperature drops and the water freezes.



CHAPTER 12

# MAINTENANCE IN GENERAL

Between the time an airplane comes in from a mission and the time it is pre-flighted for the next mission, it often requires a good deal of servicing. Knowledge of the things to look for under conditions of extreme cold will save you considerable time and effort.

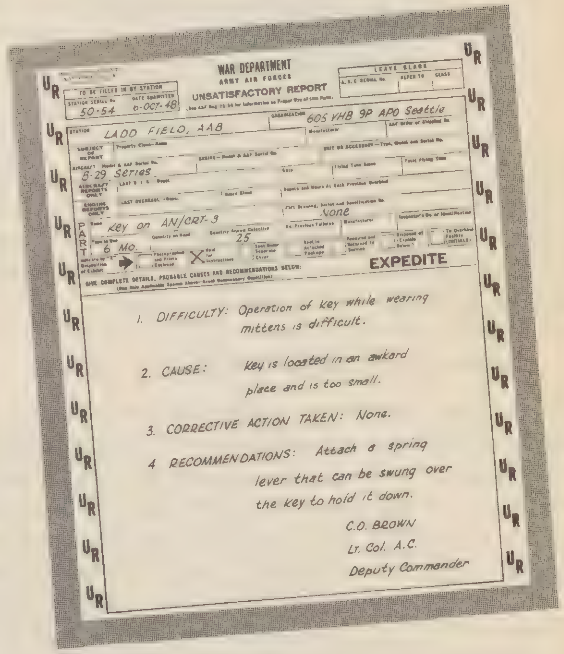
## EQUIPMENT REQUIREMENTS

The present program of the Air Force calls for airplanes and equipment capable of performing satisfactorily without extensive modifications at any temperature between −65° F and +160° F and under conditions of corrosion, dust, mildew, humidity, fungus, rain, ice, snow, sleet, or any other environmental conditions which may have an adverse effect on materiel. Naturally, the complete accomplishment of this program will take time. Meanwhile, equipment that does not meet these requirements has to be modified and winterized for polar operation. This includes such things as addition of de-icing, anti-icing, and heating equipment, adjustments for differential contraction and expansion, special hydraulic and lubricating fuels, special tires, and the like.

All these installations, adjustments, or modifications are called for in a winterization technical order (the −7 T. O.), which is prepared for each airplane classified as standard. All work outlined in this T. O. must be accomplished before an airplane is assigned for operation in the polar regions. Eventually, this work will be accomplished on the production line.

## UNSATISFACTORY REPORTS

As you work in the field, you will be in a position to observe equipment failures under various cold weather conditions. By reporting your observations to the proper authority you can perform a valuable service in getting these defects corrected. The way to do this is by filing Unsatisfactory Reports (UR's), which are designed to permit you to present a maintenance problem and your suggested correction, if you have any, through channels. These reports have proved to be the most effective means of instituting corrective measures for defects discovered in the field.


WAR DEPARTMENT
ARMY AIR FORCES
UNSATISFACTORY REPORT

LEAVE BLANK

TO BE FILLED IN BY STATION

STATION SERIAL No. 50-54

DATE SUBMITTED 6-OCT-48

ORGANIZATION 605 VHB 9P APO Seattle

STATION LADD FIELD, AAB

AIRCRAFT B-29 Series

PART Name Key on AN/CRT-3

Part Drawing, Serial and Specification No. None

Quantity Known Defective 25

Time in Use 6 Mo.

EXPEDITE

GIVE COMPLETE DETAILS, PROBABLE CAUSES AND RECOMMENDATIONS BELOW:

1. DIFFICULTY: Operation of key while wearing mittens is difficult.

2. CAUSE: Key is located in an awkard place and is too small.

3. CORRECTIVE ACTION TAKEN: None.

4 RECOMMENDATIONS: Attach a spring lever that can be swung over the key to hold it down.

C.O. BROWN
Lt. Col. A.C.
Deputy Commander

Unsatisfactory Reports usually fall into these classes:

1. Failure of equipment.
2. Unsatisfactory design.
3. Faulty material, workmanship, or inspection.
4. Unsatisfactory maintenance or supply methods, systems, or forms.

When preparing an Unsatisfactory Report, use AF Form No. 54, which you can get from the Engineering Officer. Mark the UR "Deterioration Report". Make each report specific. Describe briefly the specific defect and its cause as well as the corrective action you have taken and any recommendations you have. See AF Regulation 15-54 for detailed information on the filing of UR's.

The UR's received are compiled in a UR Digest, a Technical Order in the 00-65 series, which publicizes the information so that all may benefit from it. Your reports make the digest possible and have tremendous weight in bringing corrective action.

### PRECAUTIONS

Don't hold tools or other metal articles in your bare hands during sub-zero weather. Your skin may freeze to the article and may tear off when you try to free your hands. Watch tools and small parts when you're working in snow. If you lay them down, they'll sink out of sight. Carry them in a belt kit, keep your box with you, or lay some canvas or cowling on the ground on which you can place tools and parts.

Be careful when making emergency repairs or replacing cold equipment. Don't use too much tension when tightening nuts, bolts and cables. They will expand upon warming and may break or snap. Hose and electrical wiring are stiff and brittle in sub-zero temperatures and are easily cracked or broken if handled roughly.

### LUBRICANTS AND HYDRAULIC FLUIDS

Pay close attention to the lubricants and hydraulic fluids you use, and you will prevent many operating difficulties. All liquids increase in viscosity as the temperature decreases. Lubricants are no exception to this rule, and all tend to become stiff at extremely low temperatures. Some oils are a hundred times more viscous at 0° F than at 100° F, and a thousand times as heavy at −40° F. In addition, some lubricants may congeal at low temperatures due to the freezing out of solid materials such as wax. Generally, lubricants selected for low temperatures are the lightest possible to use and yet maintain adequate protection of moving surfaces at operating temperatures. The lubricants and hydraulic fluids procured for Air Force use are the best obtainable, with emphasis on materials which have least possible change in properties with temperature. When airplanes and equipment leave the production line, they are lubricated to operate satisfactorily in extremely low temperatures. When re-lubrication is required, use the lubricant specified by the technical order covering maintenance of specific airplanes, engines, and equipment. In addition, you will find general instructions pertaining to lubrication for low temperatures in the following Technical Orders:

| *Number* | *Title* |
|---|---|
| 06-1-2 | Fluids for Hydraulic Equipment |
| 06-10-1 | Aircraft Engine Lubricating Oils —Grades and Use |
| 06-10-4 | Lubricants — General Aircraft Use |

Remember the effect of water condensation and the change in clearances due to the difference between the rates of shrinkage of various metals. Many applications of otherwise suitable lubricants are often ruined by the condensation and freezing of a thin film of water on moving parts. The best remedy for this is prevention. Do everything possible to prevent such moisture from collecting; otherwise, you will have to use heat. The failure of parts to move at low temperatures is often the result of the reduction in clearance due to differential contraction of metals. If moving parts become inoperative after the temperature goes down a few degrees below the point where there was complete freedom of movement, a reduction in clearance is usually the explanation. The best emergency procedure in such cases is to apply heat locally.


Anti-friction (ball and roller) bearings are generally lubricated so that adequate performance is obtained at low temperatures. However, if it appears that improper lubricants have been used, clean the bearings and re-lubricate or replace them, using the procedures outlined in Technical Order 04-20A-1.

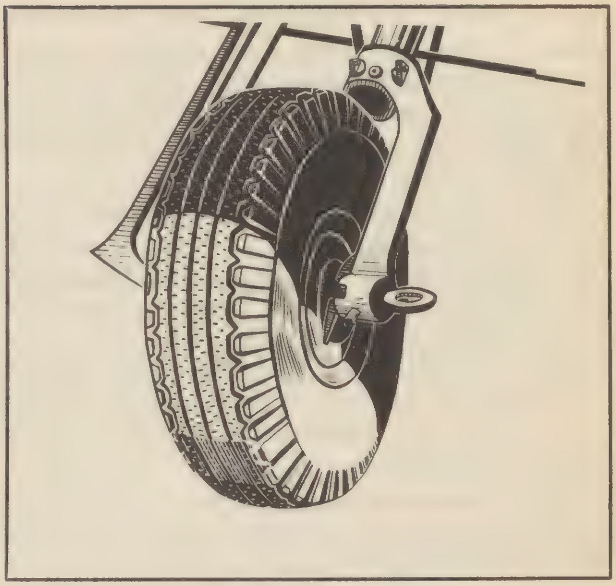
When lubrication for low-temperature operation appears necessary, remove the part, clean it thoroughly with the proper solvent, dry it, and apply the proper lubricant. Do not over-lubricate. Where it is impracticable to remove parts,

you can often displace the old lubricant by the new, particularly where pressure gun fittings are used. As an emergency expedient, add a small quantity of thinning oil directly to the lubricated part.

Generally, you don't have to dilute lubricants other than aircraft engine oil if the proper material for the particular application has been used. However, in an emergency, you may thin lubricants if necessary to obtain satisfactory operation at extremely low temperatures. Take care to provide that the diluted lubricant is replaced before attempting to operate at ordinary temperatures. A suitable general purpose diluent is Oil, Petroleum (for thinning lubricants), Specification 3601. This material has a very low pour point (below −120° F), yet is heavy enough not to evaporate and leave a lubricant with an unknown amount of dilution. Other materials, commonly used for the purpose, such as gasoline, kerosene, or compass liquid, do not have this advantage and are not generally recommended for dilution of lubricants except as a last resort.

Dilution of greases is generally unnecessary, for an adequate low-temperature grease is available. Grease dilution is undesirable also because lubricating greases have complex structures which can be harmed when the grease composition is radically changed. Make no attempt to dilute grease that is already in place, for you will only remove the lubricant from the moving parts. As an emergency expedient, if it seems that an improper grease has been used and you can relubricate in no other way, wash the grease from the part by applying thinning oil, then apply the proper lubricating oil to provide some protection for the part. Never attempt to dilute the grease of the control bearing. Tests have shown that the low-temperature properties of the grease now used for these bearings is more than adequate. If these bearings are stiff at low temperatures, the difficulty is due to mechanical difficulties, and application of heat is the best remedy.

Oils used for internal combustion engines generally have to be diluted when the temperature falls below −10° F. When necessary, dilute lubricating oils other than aircraft engine oils with thinning oil in quantities not exceeding 50%. Whenever you use thinning oil, make a more frequent check of the oil level, for the diluted lubricant will invariably be used at a greater rate.



*Helical Spring Tire.*

## SNOW AND ICE TIRES

Two types of airplane tires developed to provide additional traction on snow- and ice-covered runways are now in use:

1. A short helical steel-spring type which has numerous short sections of springs closely grouped and vulcanized in the tread.

2. A continuous steel-spring type which has strands of endless helical springs vulcanized in the tread.

Mount snow and ice tires on the main wheels only. Use them on the auxiliary wheels only if these wheels are equipped with steering devices or the Theater Commander deems it necessary for other reasons.

The continued use of snow- and ice-grip tires on clear hard-surfaced runways reduces their serviceability and life expectancy because of the rapid wear of both the metal and the tread stock. For that reason, mount and remove snow- and ice-grip tires as the weather dictates. Mount these tires in a relatively warm place. Inflate them at the lowest operating temperatures you expect with the full weight resting on the tires. If you inflate the tires in a warm hangar, they will lose pressure after standing in the cold—about 15% of their pressure for every 60° F. Low temperatures harden rubber and low pressure causes the walls to crack and pinch. Inspect the tires regularly for cuts or cracks caused by contraction from the cold.

Keep the tires free of engine oil, jet fuel, and hydraulic fluid, as these cause rapid deterioration

of the rubber. They seep under and around the edges of the imbedded steel springs, producing an oil-swelled spongy tread which tends to break the adhesive band between the rubber and the metal and results in the loss of the steel springs from the tread.

Bear in mind also that ice has a tendency to tear the springs from the tires during landing. The metal springs and tread stock may also be torn from the tires if they are permitted to freeze fast to the parking areas. When you park in wet areas, therefore, place some kind of dry insulating material in front of each tire and tow or taxi the airplane so that the tires rest on this dry surface.

Aside from preventing freezing to the ground, the insulating material also prevents deterioration of the rubber from oil, jet fuel, and hydraulic fluid.

### ELECTRICAL EQUIPMENT

Watch for corrosion of electrical equipment caused by condensation. Spark plugs, magnetos, harnesses, and leads are all susceptible to the effects of condensation. For detailed handling of storage batteries, see T. O. 30-5B-1.

Unless the airplane is equipped with an auxiliary power unit, keep the use of electrically operated equipment at an absolute minimum during ground operations, for the generators do not "cut in" and the battery carries the load until the take-off run is started. At low temperatures this is particularly undesirable, for the battery is low in power.

Storage batteries are of little or no value in sub-zero temperatures since the chemical action practically stops and it is impossible to obtain electric power from the batteries. For example, at 102° F, the standard type G-1 battery will deliver 54 amperes for 26 minutes, while at −20° F it would furnish the same current for only 4½ minutes. Similarly, a cold battery cannot be charged as rapidly as a warm one. At −20° F, the charging rate is less than one-sixth that at normal temperatures.

Therefore, if no external power is available, or if your airplane is not equipped with an auxiliary unit and you know that the airplane will be on the ground for more than a few hours, remove the batteries and keep them warm so the maximum energy in the batteries will be available for starting when they are reinstalled. Winterized airplanes will be equipped with battery quick disconnects to facilitate removal and reinstallation of batteries. On airplanes not so equipped, battery quick disconnects should be installed locally. (See T. O. 03-5B-3.)

Check the battery at least weekly. Remove the battery and charge it if its specific gravity falls below 1.240. The freezing point of the electrolyte depends upon its specific gravity. For example, electrolyte with a specific gravity of 1.250 will freeze at −62° F; with a specific gravity of 1.200, at −16° F; and with a specific gravity of 1.10, at +19° F. A frozen battery may burst. Use portable generators at every opportunity to build up the battery.

With jet airplanes, batteries are often completely dry after an average of 4 hours of flying time. Apparently, differences in temperature between the internal portions of the battery while the airplane is in flight and the outside plastic case (which is at or near the outside air temperature) cause the battery acid fumes to condense on the plastic case. This condensate is in turn vented to the battery sump jars, and the battery electrolyte and charge are eventually depleted. Due to a loss of battery efficiency, therefore, it has been found necessary to place the battery on a trickle charge overnight in order to assure positive battery action the following day. Whenever possible, use a battery cart to start an engine or to run electrical equipment. Do not operate electrically-heated flying suits, turrets, or other electrical devices unless a suitable generator is kept in operation.

The Air Force Type C-13A portable electric power plant is the one generally used as a ground source of 28.5-volt direct current. This unit is rated at 5 kilowatts for continuous operation or 6.25 kilowatts for 5 minutes. To operate it at low temperatures, follow the procedure in T. O. No. 19-45-47.

A locally improvised cart, consisting of two C-13A generators connected in parallel with six D-6A batteries across the line, is currently used in Alaska whenever power demands are greater than can be met by the C-13A. This dual C-13A is thus used, for example, in starting jet engines.

### HYDRAULIC UNITS

Check for leaks in such places as the hydraulic system, shock-strut seals, brake cups, fuel pump and accumulator diaphragms, and pressure lines to brakes. If there is continual leakage, check the type of strut packing employed. Winterized hydraulic units are identified by

special markings, indicating the type of packing employed. Check the strut air valves; these frequently give trouble. If there is leakage, put in high-pressure cores and seats designed to function under cold weather conditions. Increased leakage of all hydraulic units and connections makes it necessary to inspect the fluid level in the reservoir frequently. The breakage of bases and lines also adds to the maintenance of the hydraulic system. If continued refilling of the reservoir is necessary, check to determine where the leak is located in the system. Check all hydraulic units through their entire range of operation to be sure they are operating correctly. Most troubles are caused by broken lines, ice in the lines, sheared hydraulic pumps, ruptured diaphragms, low air pressure in the accumulator, and sticking of selector and relief valves. These conditions should show up during engine run-up; correct them before flight.

Keep a reserve supply of hydraulic fluid available in the airplane in case you have trouble with a hydraulic unit as a result of leakage.

The hydraulic filter element collects most of the moisture in the hydraulic system.Check this unit frequently for the presence of ice. Remember that ice can collect in other parts of the hydraulic system just as well as in the hydraulic filter.

### CONTROL SURFACES

Control surfaces are more often damaged in polar operations than under normal operating conditions. Running up the engines in deep snow, as well as taxiing through it, causes pieces of ice to be blown through the elevators. On airplanes that operate in snow most of the winter, it is obvious that fabric-covered control surfaces will be damaged quite frequently. The removal and installation of wing covers often injures the control surfaces. Repair tears in these surfaces under shelter, because heat is necessary to prevent the dope from "blushing", which in turn would prevent the patch from adhering; but don't direct a blast of hot air at the patched surface in order to dry the dope.

Never apply force to any fabric-covered control surface by leaning on it or by gripping it in intense cold. Because of the hardened condition of the doped fabric, cracks or "ring worms" may result which will weaken the control surfaces.

### PROPELLERS

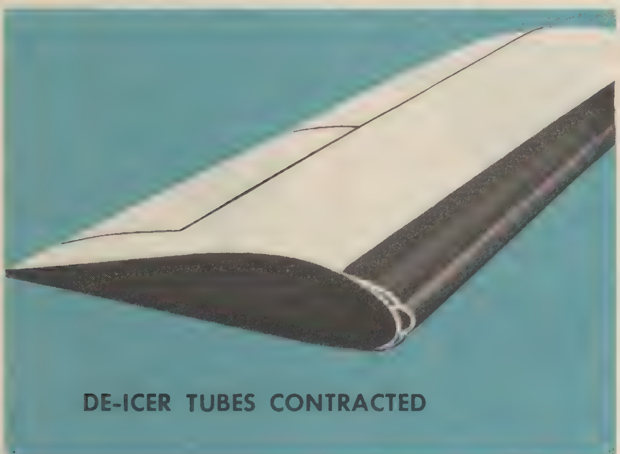
Propellers become nicked frequently and therefore require considerable maintenance. Some hollow steel propellers are subject to "wrinkling" after taxiing through deep snow. With the constant-speed governor, the pilot valve may stick if foreign matter enters the propeller system. Any congealed oil or condensation will cause unsatisfactory operation. Check propellers and governors carefully and frequently.

### CLEANING

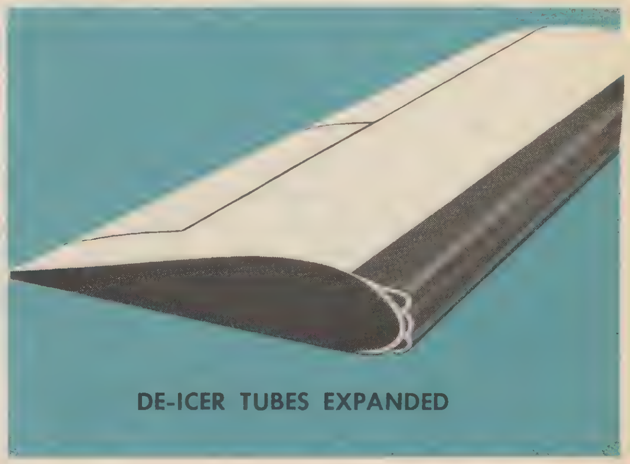
Cleaning airplanes at $-40°$ F is a problem. Experience has shown that the best method is to wipe the plane with gasoline, and then with a dry cloth. Be careful not to freeze your hands when applying gasoline. Windows and windshields can best be cleaned with alcohol.

### ANTI-ICING AND DE-ICING EQUIPMENT

Operate the prop anti-icing system. Check the de-icing equipment during engine run-up. Check all tanks of anti-icer fluid for proper level. Check de-icer boots visually for tears and abrasions caused by wing covers, ladders, or wear; don't treat them with de-icing oil.



DE-ICER TUBES CONTRACTED



DE-ICER TUBES EXPANDED

Check windshield wipers with windshields wet. Two types are in use at present; electric and hydraulic. Each has its own maintenance problems. The electric wiper must be checked for a sheared flexible drive shaft. Hydraulic wipers must be checked to see that sufficient fluid at the proper pressure is being delivered to operate the unit satisfactorily. Sticking of the de-icer distributor valve may occur, making the de-icer boots inoperative.

Keep a reserve supply of anti-icer fluid available in the plane during flight. If you are on a long flight in icing conditions, your propeller and windshield de-icers may run out of fluid.

## MISCELLANEOUS

Lubricate the gear boxes of the retractable landing lamp assemblies with the proper grease to make them operative down to −65° F.

Check solenoids; they may stick in cold weather as a result of condensation and freezing. Apply heat to them and tap them lightly with a mallet. Remove the lubrication from the plungers of starter meshing solenoids, type A-1, C-1, and those incorporated as a part of Eclipse starters, to enable the solenoids to meet low-temperature requirements.

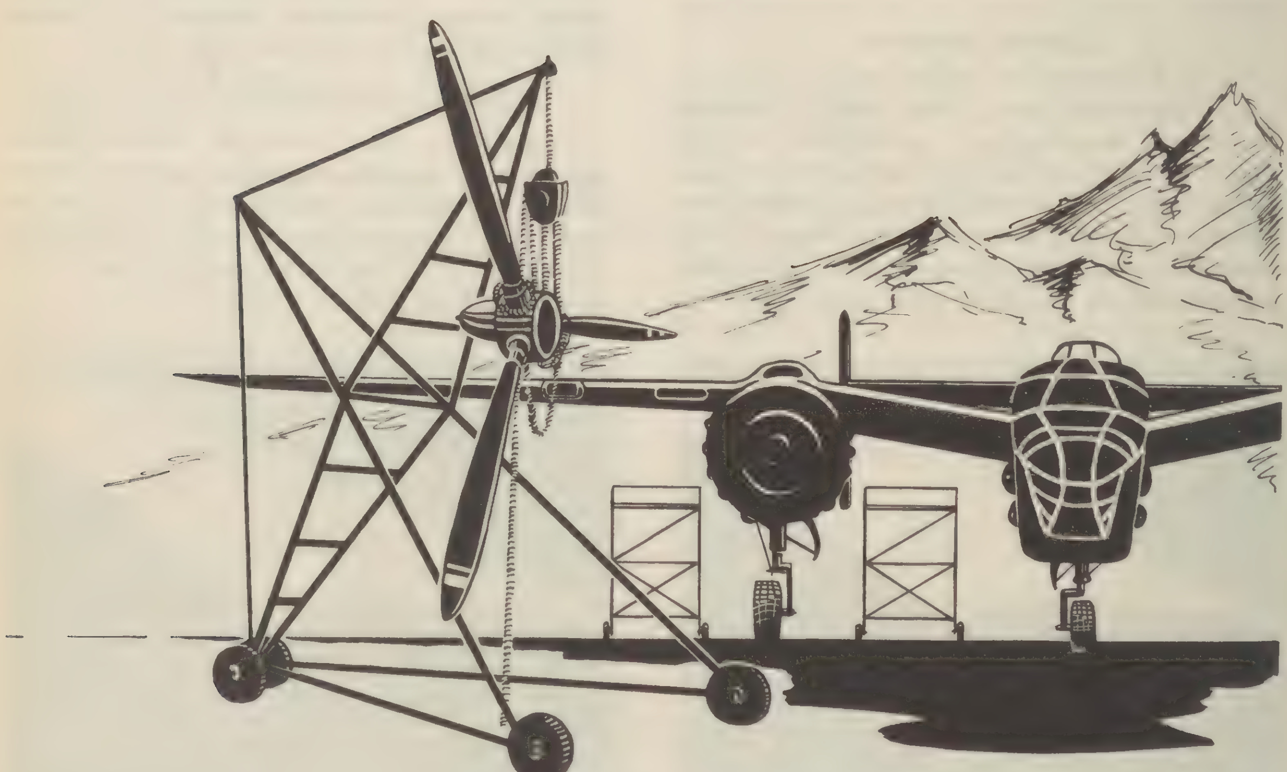
Check the operation of the boosters, the fuel transfer motor, and the fuel shut-off valve.

If the engine throws oil out of the breathers, or if there is a loss of oil pressure, check the seating of the dilution valve.

Exhaust collector rings and exhaust stacks often crack as a result of rapid cooling immediately after engine shut-down. Inspect the rings and stacks frequently.

Check the engine oil outlet connections for tightness.

Check the shimmy damper for proper operation and the antenna shock mount for deterioration.



CHAPTER 13

# MAINTENANCE OF EQUIPMENT

## INSTRUMENTS

### Aircraft instruments

Electrically operated automatic pilots will operate satisfactorily down to $-65°$ F with the exception of the C-1. This automatic pilot has electrical heating covers and should be maintained above $-30°$ F. Incidentally, make sure you put the covers on after servicing.

Air-hydraulically operated automatic pilots now installed and in stock have not been tested at low temperatures. Units at present under procurement have been tested to $-30°$ F and should provide satisfactory operation down to this temperature. If the temperature falls below this, and the airplane must remain on the "alert", heat these units by means of ground heaters to maintain the temperature of the automatic control units above $-30°$ F. If you use ground heaters, do not play the hot air from the heater ducts directly onto the bombsights or automatic pilot units. This air is not filtered and may contain dust or dirt particles and sufficient moisture to harm the units. If the units have been exposed to cold for a prolonged period, heat them by either of the two sources mentioned one or two hours before take-off. A heating period of two hours is sufficient in temperature down to $-40°$ F. When the temperature is lower, increase the heating period in accordance with the desires of the operating personnel.

You can maintain full freedom of manual control down to $-65°$ F if you use the specified hydraulic fluid in the system. Any other servo oil will not only make the automatic pilot inoperative, but will restrict the manual movement of the controls.

### Flight instruments

Electrically driven Gyro Horizon and Directional Gyro Indicators, types E-1 and C-1, will operate satisfactorily down to $-65°$ F. Air-driven flight and turn indicators (gyro horizons and directional gyros) will operate satisfactorily down to $-30°$ F. Before take-off, use ground heaters to bring the temperature of the instruments to at least $-30°$ F.

### Engine instruments

Shaft-driven chronometric tachometers are not suitable for use in extremely low temperatures and should be replaced by electric tachometers. If a flexible drive shaft is used to drive the chronometric or autosyn tachometer, clean it and re-lubricate it with winter grease to prevent binding. Remove, inspect, clean, and re-lubricate shafts with the proper grease before using them in the polar regions. Mark winterized shafts with a yellow dot on each end fitting.

Electric tachometer indicators may occasionally fail to operate immediately when you start the engine. However, these instruments become self-heating when the generator cuts in. Allow a 5- to 15-minute warm-up period before condemning the instruments.

### Oil pressure gages

Three systems have been devised to alleviate the sluggishness of oil pressure gages resulting from the stiffness of the oil in the gage line at extremely low temperatures. The systems are: the A-1 pressure transmitter system, the direct connected oil-pressure gage system, and the panel serviced type direct-connected oil-pressure gage system. For an explanation of how these systems operate and how they should be serviced, see T. O. 05-70-6.

Fill type A-1 oil pressure transmitters with the proper compass liquid, as directed in T. O.'s 05-70-4 and 05-70-6.

Whenever servicing the transmitter because of lack of indication, *never fail to look for leaks.* Filling a leaky transmitter is like pumping up a leaky tire. It will soon fail again if the leak is not eliminated. Under some conditions of cold-weather operations, condensate of moisture may collect in the manifold pressure line, causing a stoppage. To clear the line, disconnect the gage and force hot alcohol through the line. For this purpose, connect the master gage line to a container filled with hot alcohol and operate the engine at idling speed to draw alcohol through the line.

Service all directly connected oil pressure gage lines and the lines between the oil pressure

transmitter and the engine periodically with hydraulic fluid as outlined in T. O. 05-70-6.

### CAMERAS AND PHOTOGRAPHIC EQUIPMENT

Most cameras and accessory equipment designed for operation in normal temperatures will operate satisfactorily without winterization in temperatures down to approximately $-20°$ F. Winterize any equipment which is to be operated below this temperature in accordance with the technical order covering the particular piece of equipment. See also T. O. 10-1-96. Two items of the same type equipment may operate quite differently at low temperatures. Well broken in (not worn out) equipment usually will not freeze up as quickly as new equipment.

#### Cameras

Use the grease that meets the special camera requirements. Ordinary low-temperature grease may not give entirely satisfactory service life, particularly at higher temperatures, because of the low viscosity and flash point of the oil used in this grease. Use the recommended oil for cameras for all conditions including extreme low temperatures. When you lubricate cameras for cold-weather operation, use a fine hair brush and lubricate *sparingly*. Use as little lubricant as possible.

Winterizing with the recommended camera winter lubricants will permit lens shutters to operate in extremely cold temperatures at approximately the same speed as in normal temperatures. Focal plans shutters require heating.

When you bring the cameras quickly from cold altitudes to altitudes having higher temperatures or into an area where the dew point is higher than the temperature of the camera, condensation will form either as moisture vapor or as frost. When condensation forms on the lens or on the filter, blurred pictures result. Filter heater units are provided to help eliminate this condition by keeping the filter and lens at a temperature above the dew point. Warm air blown from airplane heaters on camera lenses and camera windows will eliminate much of this difficulty.

Draft seals, connecting the camera with the airplane fuselage around the camera opening, protect the photographer and crew from exterior cold and wind. You can construct the draft seals from canvas and wood. They will prove very helpful.

If lenses are subjected to too sudden or too great variations of temperatures, the separate glass elements of the lenses may split apart or show small bubbles or "check marks", due to freezing and cracking of the cement. Low relative humidity in extreme cold may also cause drying and cracking of the cement. Watch for this, as it may cause a reduction in the speed and definition of the lens, if serious. The more recent aerial and ground camera lenses are cemented with special methcrylate cement which should not give this trouble.

Cold causes a serious reduction in the power output of dry cell batteries, and you will need to make allowances for a time lag in the operation of flash gun battery synchronizers. The safest procedure is to synchronize the flash gun only for speeds (1/10 to 1/25 second) or to use only open-and-shut flash exposure, allowing the duration of the flash to determine the exposure time (averaging about 1/20 second for the most commonly used bulbs). To counteract the effect of cold on batteries in the flash gun, always carry an extra set in a pocket close to your body where they will be kept warm. Use the batteries in the gun before they become too cold to operate the synchronizer. Then place the cold batteries close to your body where, upon warming up, they will regain most of their strength. Another method is to keep the battery cells in an inside pocket and run the cord through the sleeve. Handle flash bulbs carefully in extreme cold, as there is a possibility of their exploding when flashed, and scattering glass. During operations, moisture may condense on camera lenses in the form of fog, dew, or frost from your breath, body heat, and moisture. To prevent this, hold the lens away from your face and wear thin gloves of silk, cotton, or wool when actually operating the camera, to shield the lens from the body heat.

#### Photographic film

Extreme cold causes a reduction in film speed amounting to 50% or more at $-40°$ F and necessitating longer exposures. The reflection of light from the snow and cloud cover, however, is frequently greater than can be judged by the naked eye, and pictures are frequently overexposed. Use an exposure meter, therefore, but accept its readings in the light of your experience, for its characteristics as well as those of the shutter will vary with the temperature.

Handle all films with care, particularly motion picture film. Roll film may crack because of increased brittleness in cold. The paper tabs on

film packs may tear off the film, due to freezing of the cement binder. Be careful in pulling out the tabs. In addition, the low relative humidity and the extreme cold may cause static electricity marks to appear on the film if you pull it out too rapidly or if you run roll film too fast through the camera magazine.

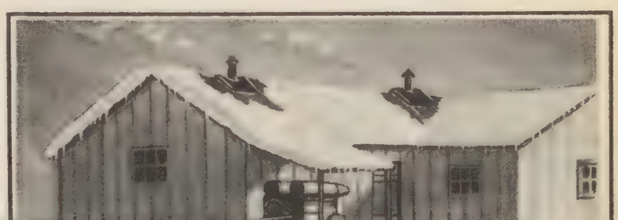
#### Photographic processing

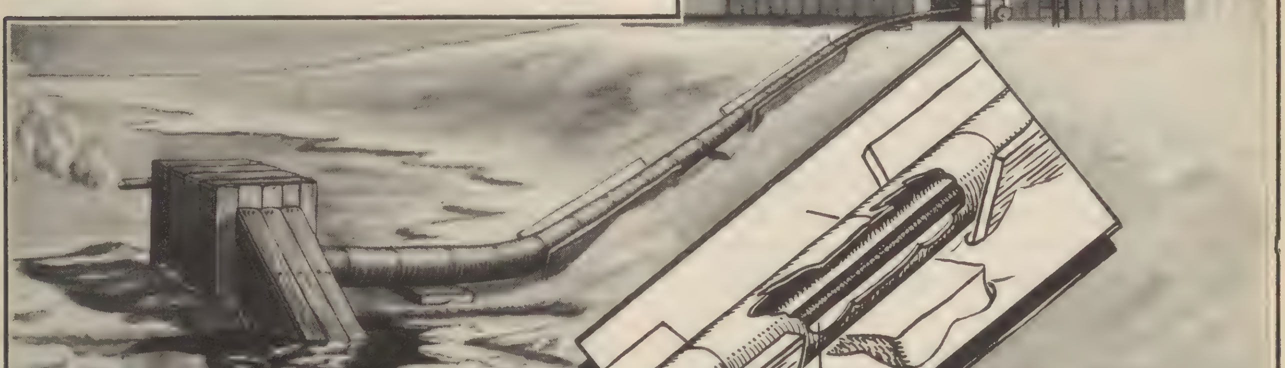
River water and melted snow are quite satisfactory for processing solutions and for washing negatives and prints. Getting water from a river in extremely low temperatures requires considerable ingenuity, for it is difficult to prevent the water from freezing on the way. One method used is to put the photographic laboratory close to the river bank and to use a garden hose inside a heater duct connected to an F-1A type heater. Another method of getting water is to melt snow in 55-gallon oil drums over a wood-fire. In washing prints and films, you will get satisfactory results for immediate use by immersion with agitation for about two minutes in each of three to four changes of water at 65° F. Before placing the prints and films in permanent files, however, you should wash them more thoroughly.

To heat solutions up to 70° F for processing, use electrical hot plates, stoves, and immersion heaters. You can process cold film immediately without waiting for it to warm up before placing it in the developer. Glossy surface prints must be soaked in a strong glycerin water solution before ferrotyping, to prevent the cracking and curling caused by the low relative humidity in most polar laboratories. Do not dry wet film in air at below-freezing temperatures; the film may freeze and crack in drying. If it is necessary to dry film in a cold laboratory, immersion in alcohol before drying may help to prevent freezing. If the film turns milky on being placed in alcohol, add 1% of salicylic acid. Most polar dark-rooms are cold near the floor, with heat increasing toward the ceiling. If you dry film on a drying rack, hang it so that no part of it will dry at a different temperature than the rest, or a streaked negative may result. Placing fans in the proper positions to force circulation of the warm air from heaters within the laboratory will help to equalize this difference of temperature between the floor and ceiling.

#### Storage of photographic material

In order to prevent condensation of moisture and subsequent freezing when cameras are taken from the outside cold into a warm room and vice versa, store and load all cameras and film in a temperature at, or near, freezing. This will also prevent cracking of the balsam cement in lenses. If you need to take a camera, lens, or film from the outside cold into a warm room, bring it up to the inside temperature gradually by allowing






*Getting water from river.*

it to warm first in a room or compartment of intermediate temperature between the inside heat and outside cold. Freezing of developing and fixing solutions and storage of exposed and unexposed film in extreme cold appears to have no bad effect on the activity of these materials when thawed out, provided that hydroquinone is not the only developing agent in the developer. Do not fill jugs of processing solutions to more than about 80% of their capacity or they may crack, due to expansion of the solutions when frozen. An insulated box with a small heating unit is good for storing processing solutions not in use.

#### Portable photographic laboratories

With the use of a suitable shelter (Type B-2 portable shelter) the dark-room kit with field processing equipment, has proved very satisfactory for polar laboratories. The Type B-2 portable shelter provides a semi-permanent building which is weatherproof, of durable construction, yet light and compact enough to be airborne equipment. You can made this building into any size laboratory by merely adding partitions. This building will also be suitable for a darkroom if you make it light-proof. The U-1 darkroom fits inside this building.

### MACHINE GUN TURRETS

All machine gun turrets will operate down to −65° F, if you follow the proper maintenance procedures. Be careful to use approved low-temperature lubricants and hydraulic fluid. If you have doubts about the lubricant in a bearing or gear, remove all traces of the lubricant according to the procedures in the appropriate technical order. Then repack the gear or bearing with the proper lubricant. Similarly, if you have doubts about the hydraulic fluid in any hydraulic turret or power-operated gun mount, drain and flush out the hydraulic system according to the procedures in the appropriate technical orders and refill with the correct fluid.

#### Ground operation

Never operate a turret directly from the airplane battery. Use an auxiliary power unit. To prevent damage to the motor, never operate a turret at less than 24 volts. Use an adequate current supply at the proper voltage during ground operational checks. While you may use a 70-ampere power source with a battery floating in the line, a 100-ampere source is preferred.

On turrets with computing sights, turn the sight on just before throwing on the turret main power switch.

Check the following equipment for proper operation before each mission:

Structural and fire interrupters (check clearance of all danger areas), gun heaters; gun chargers; gun solenoids; interphone circuit; sight bulb or lamp; rheostat; filter glass; limit stops; ammunition boosters; manual controls for emergency operation; emergency firing device; oxygen supply and equipment; heated suit rheostat; hydraulic fluid in hydraulic reservoir; brushes (check arcing, length, etc.); harmonization of sight and guns; and commutator (check for dust, dirt, and other foreign matter; also for excessive or uneven wear).

Technical orders under the 11-45 and 11-70 series cover detailed operation and maintenance instructions on all turrets.

Use a soft cloth or chamois in washing the exterior surface of plexiglas domes. Remove oil and grease by rubbing lightly with a wet cloth dampened with kerosene, hexane, or white gasoline (not aviation or ethyl). Dust the interior surface lightly with a soft, clean damp cloth. *Do not use a dry cloth.* At extreme low temperatures, be sure to use one of the appropriate cleaners mentioned above. Water cannot be used for cleaning plexiglas below 32° F. In removing foreign matter, be very careful to avoid scratching the surface.

For ground or aerial operation at low temperatures, allow the drive system five to ten minutes to warm up before operating the turret. During a mission when the turret is not in continuous operation, operate the turret for at least ten minutes each hour.

Turn the gun heaters on just before take-off.

For ground operation, pay special attention to the motor after turning the power switch on. If the motor does not start immediately, turn the switch off without delay to prevent serious damage to the motor. Then check the voltage at the turret power terminals. If the voltage is below normal operation voltage, adjust the voltage; if it is impossible to adjust the voltage, use another power unit. Should this not help, apply heat to the motor. If heat is not available, continue trying starts at four-minute intervals. These attempts should heat the motor sufficiently for a successful start.

## MACHINE GUNS

Electric gun heaters are installed in certain gun installations to maintain the guns in firing condition at low temperatures. Three types of heaters are used on the caliber .50 gun—J-1, J-3, and J-4. The J-1 heater consists of an "L" shaped metal housing which fits over the top cover in such a way that the heating pads contact the side plate opposite the bolt. The J-3 is a conducting neoprene pad which is cemented to the gun side plate. The J-4 heater supersedes the J-1 and J-3. It is smaller and more efficient than the J-1. Turn the gun heaters on just before the take-off.

### Condensation on gun parts

When aircraft weapons are exposed to low temperatures and brought into warm buildings, moisture condenses on them and causes rusting. Therefore, wipe them dry and re-oil them immediately after they have warmed up to building temperature. This procedure is necessary each time the material is brought from a cold to a warm temperature. Weapons to be fired in extremely low temperatures should be oiled in such a manner that the oil film is not visible. All moving parts should have a very light coating of oil. Applying a heavy film will result in a stoppage of the weapon, since the oil will congeal and cause a sluggishness or freezing of all moving parts. Check oil buffers and recoil mechanisms before each firing mission. When not in use, check them approximately every fifteen days. When the guns are in the open, and not in use, cover all unprotected parts with tarpaulin or other suitable material. Select a firm covering so that no loose material will get into the working parts of the guns.

## SIGHTS

Check the applicable technical order in the 11-35 series for specific information on the cold-weather operation and maintenance of the sights on your plane.

## BOMBING EQUIPMENT

Except for bomb hoists, bombsights, and the C-1 automatic pilot, all other bombing equipment is operated dry—no special lubrication is necessary.

None of the bombing equipment has to be removed from the plane and brought inside the shelter. Leave all the equipment, including the bombsight, in the airplane. Remove the bombsights from the plane only when you have to carry out calibration checks or re-lubricate parts. In this way, condensation forming on cold equipment brought inside does not become a serious problem. By observing the above procedure you will be sure to prevent deterioration of precision equipment.

You do not need especially to protect bombing equipment on airplanes left exposed in the polar regions. Just keep the bombsights covered. If covers are not available, keep the bomb bay doors closed during the exposure period, but leave an opening in the cockpit to prevent the windows from frosting.

## ELECTRONIC EQUIPMENT

### Causes of equipment failure

Very little difficulty is experienced with electronic equipment in the polar regions. However, there is the problem of moisture condensation when cold equipment is brought into a warm enclosure. In addition, the coastal areas of most polar regions are subject to dense fog in spring and fall, and in these areas and seasons, moisture condensation and corrosion are factors which may cause resistance leakages and high voltage arc-overs.

Under extremely cold conditions, particularly at −40° F or lower, electronic equipment may fail to operate for a variety of reasons. Certain components such as dry cell batteries will not work at all at these temperatures. Changes in the resistance, capacitance, and inductance of components may be so great as to necessitate frequent readjustment of critical circuits. On the AN/ART-13 transmitter, for example, the power amplifier output circuit becomes detuned with a temperature drop of 10° below 0° F. Rotating shafts, gears, bearings and other moving parts may freeze and become mechanically inoperative.

### Preventive Maintenance

GENERAL. When temperatures fall below 0° F, apply heat to electronic equipment if it must be ready for immediate use. Batteries and electrolytic condensers in particular may require the application of heat to operate normally. Long warm-up periods by tube filament heating is good practice because it helps to bring equipment up to proper operating temperatures. Follow technical orders for instructions on warm-up time. Be sure to increase this warm-up time for extremely low temperatures. If possible,

operate ground equipment in buildings which are heated both by day and by night.

The operation of mechanical parts which are not lubricated, such as shafts and bearing surfaces, will be improved if you keep the moving metal parts buffed and carefully polished. Where lubrication is necessary, lubricate *sparingly*.

When you bring cold equipment from outside into a warm room, moisture may condense on it. Wipe off all visible moisture carefully. Don't place the equipment near a hot stove or bring it into enclosures where the temperatures are higher than 90° F.

CONDENSERS. Ordinarily, condensers are not likely to fail at low temperatures. However, electrolytic condensers are subject to considerable variation in capacity and in effective series resistance, especially at temperatures below 0° F. Capacity decreases with the temperature while resistance increases. At temperatures around −40° F, electrolytic condensers have little value as audio by-pass and power filter condensers because of their greatly reduced capacity. Generally, they will return to normal following temporary exposure to low temperatures.

If wax-impregnated condensers are exposed repeatedly to extreme cold, the sealing properties of the potting compounds will be impaired; the life of the condenser will be shortened and, if moisture gets in, there will be a large change in capacity, as well as AC losses. The best preventive maintenance is to keep the equipment warm and dry.

ROTATING SHAFTS, GEARS, AND BEARINGS. Of all the difficulties most likely to be encountered in extreme cold, the freezing of rotating shafts, gears, and bearings is the most troublesome. Treat these parts for cold-weather operation. For proper lubrication, follow specific instructions in technical orders. Carefully remove all original lubricating grease and oil by washing the parts thoroughly in cleaning fluids such as benzine or naphtha. Use low-temperature grease for lubrication.

ANTENNAS. The weight of ice can cause antenna wire to break or may reduce the operating range. Check all antenna installations frequently. Knock off icicles with a thin pole. Remove all ice from the strain insulators to prevent excessive transmission losses. Keeping the antennas a little loose is helpful, for they will whip slightly and break the ice off.

CABLES. Don't bend cables at sharp angles; insulation may crack and lead to failure of equipment. Moisture-proof equipment moved through temperature gradients in accordance with T. O. 16-1-41. While this technical order deals with tropicalization, the methods of moisture-proofing apply to the polar regions as well.

INVERTERS, DYNAMOTORS, GENERATORS. Even though the ball bearings of inverters are lubricated with cold-resistant grease, starts in extreme cold may still be difficult. Before operating, warm the inverter by means of a hand heater or other suitable heat source.

#### Operation

INTERFERENCE. HF transmission is often completely blacked out in the polar regions, and some interference is encountered on VHF transmissions. Low frequencies are the most likely to get through. The cause of the interference is not thoroughly understood, but it is believed to be the result of magnetic disturbances resulting from the aurora or sunspots. Investigations are now being conducted on this subject, and predictions of the time and coverage of the disturbances are being made with a fair degree of accuracy.

CHANNEL SELECTION. To avoid difficulties in selecting channels on push-button type equipment (SCR-522, ARC-3, etc.) because of extreme cold, it is good practice to set the equipment on the desired channel before starting on the mission.

TYPES OF EQUIPMENT. Low frequency Loran is being installed throughout the Far North because of its effectiveness for navigation in those areas. Similarly, GCA is installed and in use in practically the whole region. To provide complete air warning, IFF equipment is coming into actual use. In many airplanes, the ARN-11 radio compass is installed in addition to the ARN-7 to provide for better fixes and possible malfunctioning of the radio compass.

### MISCELLANEOUS EQUIPMENT

#### Instrument test set

When you use the type C-1 instrument test set in the field at low-temperature conditions, give particular attention to the proper lubrication of the set in accordance with the lubrication chart mounted in the lid.

Electric driving motors in the type C-1 test set that are marked with a yellow dot near the name plate have been serviced with low-tempera-

*Keep antennas free of ice.*

ture operation grease. Prepare any that are not marked for low-temperature operation by first removing the motor bearing grease cup and cleaning out all the old grease possible from the cups and motor housing. Then add twenty to thirty drops of the proper compass liquid to the motor bearings to thin out the old grease that still remains, and refill the grease cup with low-temperature grease. You may have to repeat the above procedure at frequent intervals until the low-temperature grease works into the motor bearings and the motor operates satisfactorily at low temperatures. Do not attempt to disassemble the motor and bearings, as this operation requires the use of special tools and is not necessary if you followed the procedure just described.

**Hydraulic jacks**

If the pump fails to pump or the jack fails to lower with the lowering valve open, heat the pump body (a blow torch is suitable) to throw out moisture that may cause the check valve to stick or the lowering valve opening to open.

Be sure the air vent screw does not freeze closed while the jack is being lowered since excessive pressures may burst the oil reservoir.

For operation below $-20°$ F, use a mixture of 60% hydraulic fluid (Spec. AN-0-366A) and 40% kerosene or jet fuel (Spec. AN-F-32) in the jack. Replace chevron seals on the jack ram with "O" rings to prevent leakage and insure operation. If the jack has already been so modified, it will have an "O" painted on the cylinder.

To prevent slippage on icy surfaces, drill and tap the jack feet, place standard set screws, pointing downward, in these holes, and secure them with lock nuts on top of the jack feet. If necessary, you may sharpen the points of the screws. Three set screws per jack foot give the most satisfactory results.

Where a great deal of lifting power is required, as in accidents involving collapsed landing gear, pneumatic lifting bags are useful.

**Fire extinguishers**

Winterize carbon tetrachloride fire extinguishers in accordance with T. O. No. 03-45B-2. Winterize carbon-dioxide type fire extinguishers in accordance with T. O. No. 03-45C-11 to provide for satisfactory operation down to $-65°$ F. Be particularly careful to keep the $CO_2$ absolutely dry, or moisture will freeze in the valves, preventing discharge.

**WARNING**

Never use carbon tetrachloride fire extinguishers in confined places since the fumes (phosgene) are toxic.

**Field maintenance shelters**

During cold weather operations involving ground maintenance of airplanes, use types A-1A and A-3A shelters for protection while working on the engine. When erecting the type A-1A shelter in sub-zero weathers, be careful when

putting the cover over the frame. Do not use force, as this will break the water-proofing on the cover. Warm the coated duck cover on both sides by hot air from the type F-1A ground heater until it becomes pliable and will stretch easily into place. The plastic windows break easily at low temperatures. Remove them and cover the opening with duck material.

*Pre-heating compressor.*

**Air compressors**

Cold-weather starting and operation of gasoline engine-driven air compressors require:

1. Good spark.
2. Proper carburetion.
3. Proper lubrication.
4. Disengagement of compressor and engine until after engine is running and warmed up.
5. Preheating of compressor crankcase.

Check the breaker points for contact and correct gap. It is also important to adjust the carburetor properly. However, do not tamper with carburetor adjustments unless the engine does not run properly under load when warmed up.

Remove the belts of belt-driven compressors and start the engine alone. When the engine is warm and the compressor crankcase has been heated, stop the engine, replace the belts, and re-start the unit.

For small compressors equipped with an automatic clutch, once the engine is started, keep it at a low speed by holding the throttle almost closed until the engine is warmed up. Then you can speed it up until the clutch engages and drives the compressor. Be certain that the compressor will turn over and is not "frozen." If the compressor is very stiff and the clutch just slips instead of driving in, you may have to pre-heat the compressor to warm the oil.

If a normal clutch is provided, you can easily disengage the compressor and engine to facilitate starting. When engaging the clutch, be certain to ease it in.

If portable ground heaters are available, preheat the engine and compressor. If not, you can get heat from the engine itself.

For temperatures down to about −30° F, you can make cold starting of the compressor easier by building an enclosure of cardboard or lumber around the engine and compressor base to direct the engine exhaust heat towards the compressor crankcase, thus pre-heating it. Restrict the cooling air to the engine but don't stop it completely. Once the unit is operating properly, remove the enclosure. Normal operation will generate enough heat to keep the compressor and engine warm. Do not restrict the cooling air nor heat the compressor.

For temperatures below −30° F, follow the same procedure but restrict the engine cooling air and apply some exhaust heat to the compressor crankcase when the unit is running.

**Air-operated high-pressure air pump**

Satisfactory cold weather operation of this booster requires that either absolutely dry air be supplied to run the booster or that it be operated in heated or warm and insulated containers.

An air drier is being developed at the present time, but, until it is available, you can fabricate a suitable drier locally from a type A-3 oxygen purifier cartridge or you can fill a suitable container with silica gel.

You can winterize the high-pressure pumps mounted on M-2 tractors or on the side of the gasoline engine-drive, 5-cubic foot capacity air compressors by constructing an insulated box around the pump and piping the engine exhaust through the enclosure. Insulate the exhaust pipe to the box and install the muffler at the point of discharge from the box.

# PART 4

# OPERATIONS

# PART 4

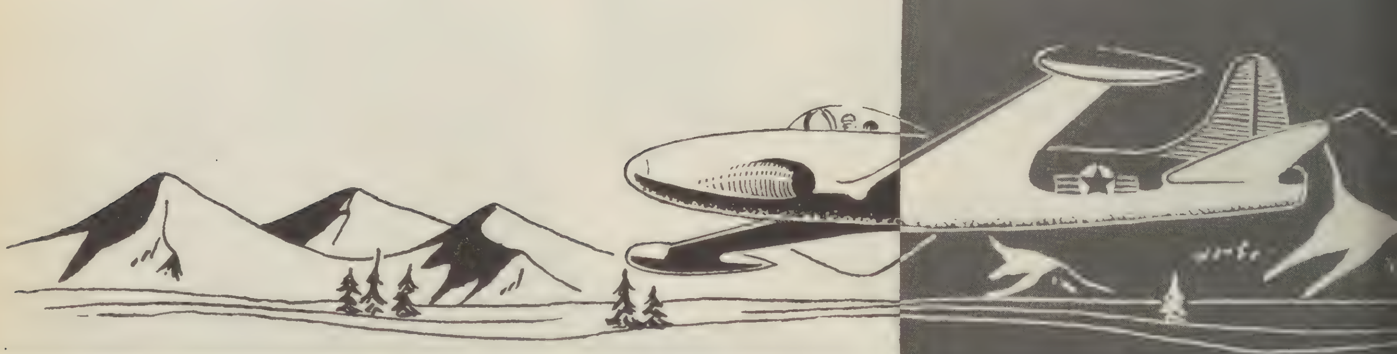
CONTENTS



Successful polar operations depend on many things, including careful and detailed flight planning, thorough mastery of all-weather flying, understanding of polar navigation and communication, and — above all — good judgment.

These are the qualifications for good flyers anywhere, but in the polar regions, they are especially important because of the extreme conditions that occur there. Of course, much of this knowledge and ability comes only as a result of long experience. But a good start can be made through careful study of the principles involved.

This part of the guide is an introduction to the problems and techniques of polar operations. It does not tell you the whole story, but it does give you a framework upon which to build a real understanding of polar flying.



CHAPTER 14

# PREPARATION FOR FLIGHT

Polar operations require considerably more preparation for flight than operations anywhere else in the world. Not only must you prepare the airplane and the accessory equipment for proper functioning under special conditions, but you must also prepare yourself for any emergency. If the flight is not properly planned, the mission may be doomed to disaster even before the plane leaves the ground. If you are not prepared for emergencies, even a well-executed crash landing may really be the beginning of a long, slow funeral.

Before take-off, be sure to learn the location of inhabited outposts, emergency cabins, or other shelters, and the whereabouts of crash boats and patrol vessels. Know what rescue equipment is available and what the established search and rescue practices are. Ascertain the proper procedures in foreign territory from your Intelligence Officer. Learn the distress, bail-out, ditching, and crash landing procedures as prescribed by your training and briefing officers. Be sure you know. Don't guess. It's your life.

Polar operations also require careful planning and scheduling of pre-flight ground activities. Arrange the periods of pre-heating so that all equipment will be inspected, warmed, ready, and operating at the time of starting engines or take-off. While necessary pre-heating is taking place, ice and snow should be removed, inspections and operational checks made, electronic equipment warmed up (with external power source connected, of course) and other necessary activities conducted. In general, maintenance crews must know the overall time (including time for pre-heating the heaters) required for preparing the airplane for flight at any given temperature. Similarly, there must be thorough coordination between the Engineering and Operations sections so that there will be no costly delays between the conclusion of the pre-flight and take-off.

## PERSONAL CARE

The importance of the proper care of your person in the polar regions has been stressed in many places in this guide, but here are a few additional suggestions for your personal comfort and safety.

Many different kinds of polar flying clothing have been devised. Naturally, you will wear what is issued, but, in general, be sure you have the proper clothing to keep you warm in case of a crash landing. Wear a parka, an intermediate jacket, flying trousers, mukluks, and the proper glove and sock assemblies. Dress for the worst possible conditions, not the best. An electrically heated flying suit is very fine in the plane, but if you crash land, it's pretty hard finding a place to plug it in.

In addition, remember the effect of cold metal on your skin. Wear gloves, of course, but just to make sure, wrap tape, cord, or cloth muffs around control sticks or wheels, throat and hand mikes, and any other parts you might have to touch.

Keep out of prop wash. The blast can cause severe frostbite in the polar regions.

## WEATHER

Flying in polar weather is difficult and taxes your instrument flying ability and your knowledge of weather conditions to the utmost. Nowhere else does the success or failure of your mission depend so much on your judgment. However, according to bush pilots who have studied and flown polar weather for years, you can master the technique if you follow a few simple directions.

Review everything you ever knew about meteorology, and then learn some more. The most important document you will ever see during service in the polar regions is a weather map. Fifty percent of a successful mission involving bad weather is accomplished on the ground. So work out the entire flight on paper, taking into consideration the conditions at destination, alternate airports, route weather conditions, available aids to flying along the route, time element, load conditions, *and* your ability to execute the job. Figure on a fair margin of fuel supply and load. Know the limits of your airplane and instruments in weather con-

| | % of Time Ceiling and/or Visibility was below | | | | | |
|---|---|---|---|---|---|---|
| | 1000″ and/or 3 miles | | | 2000′ and/or 6 miles | | |
| | Jan | July | Annual | Jan | July | Annual |
| Aleutians (Adak) | 16 | 43 | 23 | 42 | 78 | 54 |
| Interior (Fairbanks) | 8 | 2 | 7 | 15 | 5 | 14 |
| Gulf Coast (Anchorage) | 15 | 3 | 8 | 22 | 7 | 12 |
| Southeast Coast (Yakutat) | 20 | 32 | 25 | 47 | 62 | 51 |
| Seward Peninsula (Nome) | 9 | 44 | 21 | 29 | 48 | 28 |

*Typical Flying Conditions in Alaska.*

ditions. However, do not try to gage the weather too closely.

In general, the number of clear days among Alaskan bases is seldom over half the total number and often less than one-third. Nearly all bases, except in the interior, average more cloudy than clear days in the course of a year. The Aleutians, the southeast coast, and Seward Peninsula experience their best flying conditions during the winter, whereas the Gulf coast and the interior have their best flying conditions in summer. The best flying weather for all Alaska occurs in the interior and the parts of the Gulf coast which are well protected from the maritime influence, such as the Anchorage area.

Judging by ceilings and visibilities, the poorest flying conditions exist in the Aleutians and southwest regions. The ceilings and/or visibilities are below 2000 feet and/or 6 miles a little over 10% of the time (annually) in the interior and Anchorage area, and over 50% of the time in the Aleutians and southeast coast.

Note the brief comparative summary shown above of the flying conditions for the various parts of Alaska, as observed at the bases indicated.

Thus, generally speaking, the weather is bad as compared to Zone of Interior conditions. Nevertheless, it is flyable if the airplane and crew are prepared for it. This means airplanes in good condition, fully winterized, with deicing and anti-icing equipment, and with radio and electronic aids for navigation and low approaches. It means also pilots well-indoctrinated in instrument flying, including navigation, letdown, and low-approach.

## AIRPLANE CHECK

The particular items that need to be checked in the pre-flight inspection of the airplane are covered in Chapter 10. Here, however, are a few special precautions you must take just before the flight.

Clear all frost and snow from the surfaces of the plane before take-off. Even a very thin layer of hoarfrost an eighth of an inch thick will alter the take-off characteristic of your plane. Loose snow will not blow off during take-off and may cause you either to stay on the ground until you reach a dangerously high speed or, worse still, to stall during the initial climb. Remember, the thinnest film of ice forms a base upon which more ice can and will form rapidly.

Frost will usually form on the windows either during engine warm-up or when you enter the plane. Remove this frost by blowing hot air into the cockpit through a heater duct or by using alcohol, gasoline, or copper or steel wool. However, do not use copper or steel wool on plastics. You can keep windshield frost down to a minimum by sitting well back and not breathing directly on the windshield.

Inspect all main and auxiliary control hinges and surfaces for particles of ice or hard snow that might cause jams. Check all controls to insure free and easy movement and full travel without blockage. Also check the pitot heat control and make certain that heat is available for the windshield.

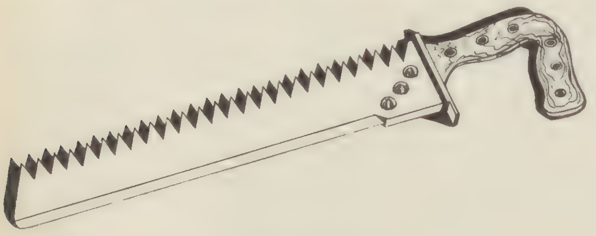
## EMERGENCY EQUIPMENT CHECK

*Check all your emergency equipment before starting out on any flight.* You may find an important item missing, perhaps the very item you will need if you are forced down. Check also to make sure that the parachute harness fits properly over the clothing you're wearing at the time. Different adjustments may be necessary for different missions.

E-18 BASIC AIRPLANE KIT

Store the emergency equipment securely in an easily accessible place so that it can be removed rapidly in an emergency. Make the lashings simple and anchor them by small loops of rope. This makes it possible, in an emergency, to cut the loops, remove the equipment quickly, and preserve the main rope for later use.

The standard emergency kit is the E-18. One of these kits is supplied for each three men in the airplane up to a maximum of three kits per plane. The E-18 is a basic emergency kit which contains supplies for emergencies anywhere in the world. To make it applicable to the polar regions, replace the items in the kit that are not appropriate for cold-weather survival with such items as you will need. For example, replace the machete with an ice-saw snow-knife made up as illustrated. It is good for digging snow caves



*Ice-saw Snow-knife.*

as well as cutting ice blocks, or sawing driftwood or frozen timber. In winter, also replace the gloves in the kit (which are really for protection against mosquitoes) with the glove assembly for cold-weather wear. Similarly with the other items in the kit—take along such as are most useful in the region over which you are flying.

Wear a C-1 or C-2 emergency vest. Here, too, replace or supplement particular items according to the season of the year and the region over which you are flying. Check with your Personal Equipment Officer as to the best things to take along.

Take along one or more barren land tents (described in detail on page 18-9) depending on the number of persons aboard. These tents, which even inexperienced personnel can erect easily, each accommodate three or four men and can withstand winds up to 100 mph.

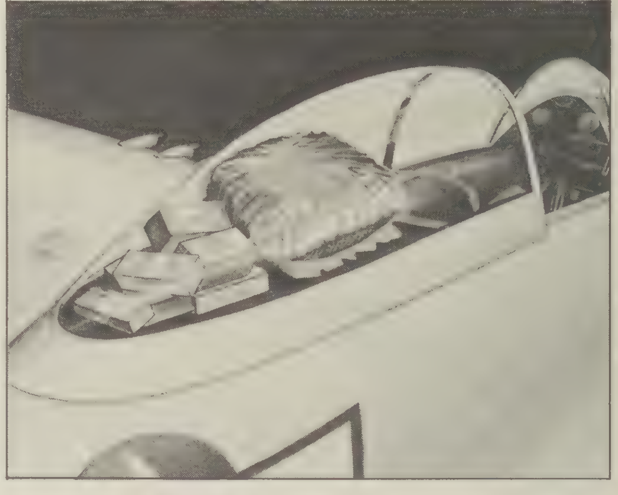
If conditions permit, it's a good idea to take along also an E-12 kit, normally carried by rescue planes. This will provide you with many items you will find useful in case of an emergency. If you can't get an E-12 kit, be sure to take along extra clothing, sleeping bags, emergency rations, and the like.

When flying over regions where mountains and glaciers are widespread, carry crampons; snowshoes; packboard, one for each two men; blankets; a plywood sled with collapsible runners; rain suits and shoepacs for summer; windproof parka and trousers; extra mitten shells; manila rope, 120 feet for each four men; ice ax, one for each four men; tarpaulin; and extra gasoline cooker (for heating shelter).

When flying over water areas also carry anti-exposure suits, Mae Wests, life rafts, and life raft kits as emergency equipment.

Even in a fighter, you can carry some emergency equipment. Seat and back packs to hold the maximum amount of survival materials compatible with cockpit space are being developed. These packs will probably not come filled with pre-selected materials. Instead, the various kinds of survival equipment will be available in supply, and (unless there is a local regulation stipulating what should be taken) it will be up to you to select the items you deem most important. Be sure to take along as much as you can. In some fighters, a shelf of sheet steel has been built into the rear of the canopy for emergency supplies. If at all possible, have such a shelf built in your plane. You can hold the emergency equipment in place on the shelf by placing the bed roll in front of the smaller articles.

At present, some fighter pilots are working out arrangements to carry blankets or a sleeping bag on their backs. However, research is progressing in the development of a compactly packed sleeping bag that can be put into a seat or back pack.



CHAPTER 15

# FLIGHT TECHNIQUE

## WARM-UP

Warm up the engine thoroughly. In extremely low temperatures, use carburetor heat immediately after the engine is started. It improves fuel vaporization, prevents fouling of the spark plugs, and helps make the engine run smoothly. It also prevents ice formation and insures the elimination of all ice from the induction system.

Adjust the cowl flaps to the degree of opening necessary for normal cylinder head temperatures. Watch your cylinder head temperatures, though. Excessive temperatures may be reached in portions of the engine compartment at take-off power if the cowl flaps are fully closed.

When warming up the engine, make sure that no personnel, ground installations, or other planes are in your prop wash. A blast of snow- or moisture-laden air can undo hours of maintenance work.

Never turn on electrically heated suits, or any other electrical equipment not absolutely needed, until the generators show output. Storage batteries are of little or no value at subzero temperatures and an attempted use may ruin the battery or electrical equipment.

## TAXIING

When taxiing take the same precautions as when warming up the engine to prevent your prop wash from hitting personnel or other airplanes.

Use sufficient engine power while taxiing to keep the engine warm and prevent it from dying out. In loose snow, hold the stick or wheel well back and keep momentum. Avoid abrupt turns, but if you must make them, use a minimum of differential braking; otherwise, the wheel will pivot and dig in. The nose wheel has less tendency to trail properly as the depth of the tire-sink increases. The small diameter of the nose wheel can cause it to dig in even while the main wheels move freely. Thus, in deep snow, the nose wheel takes the full thrust of the engines. Raising the elevators will relieve the pressure, but thoughtless gunning will result in the caving of the nose strut. An abused strut, even if it does not collapse, will be out of round at the packing gland, causing leaky packings. Damage can also occur to the propellers and engines if the propellers come down far enough to hit their tips on the snow.

If deep, heavy snow interferes with the take-off run but permits the airplane to taxi, move slowly up and down the take-off course several times to pack down the runway before attempting the actual take-off. The depth and hardness of the snow, together with the airplane wheel size, will determine whether take-off or landing is practicable. In slush or deep snow, moisture may get into the brake drums and freeze when you stop to run-up your engines. Be careful not to stop in deep snow. Watch out for obstacles hidden by freshly-fallen snow.

Watch for frost formation. Although not particularly dangerous during flight, frost can cause trouble during take-off.

Jet airplanes taxiing close behind each other or making turns out of the parking line become coated with ice from the slush and snow blown at them by the preceding airplane. To prevent this condition, jet airplanes must be kept at least 200 to 300 feet apart when taxiing.

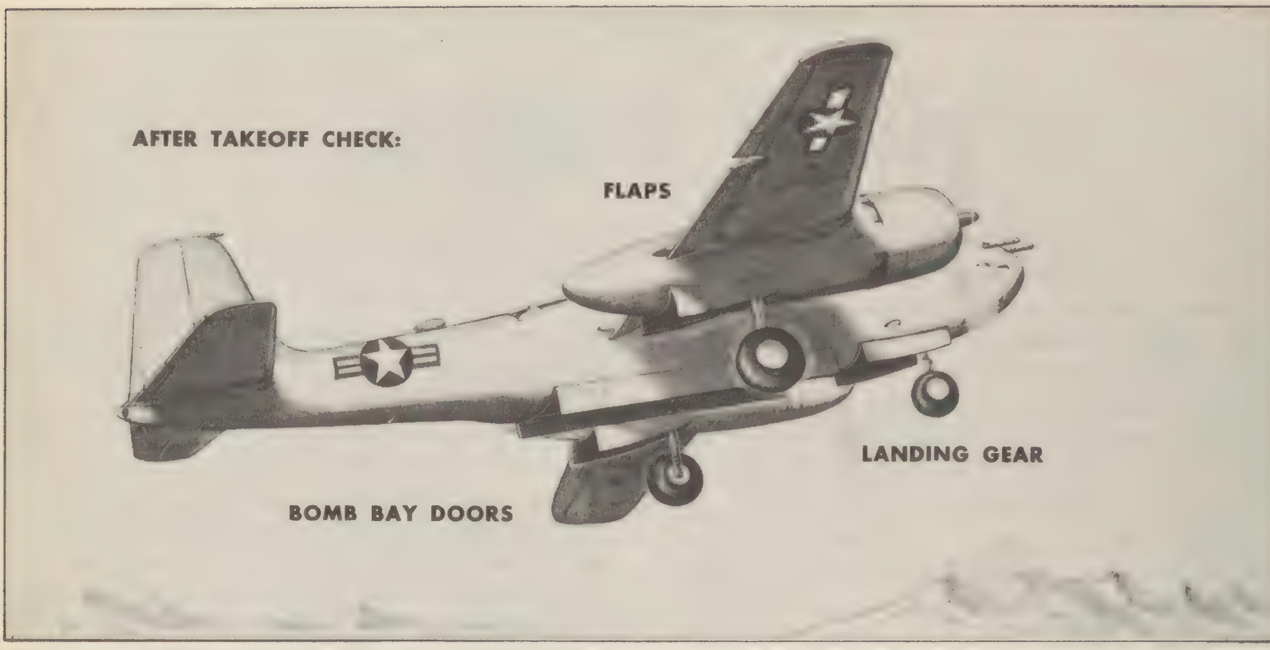
## THE TAKE-OFF RUN

Be careful not to take-off with over-diluted oil. With engines that scavenge satisfactorily, it's safe to take off immediately without the normal warm-up, *provided there has been a rise in oil temperature, oil pressure is steady, and the engine is running smoothly.* Cold oil properly diluted has the same viscosity as hot undiluted oil, and therefore the same ability to circulate and properly lubricate the engine.

In taking off heavily loaded aircraft from snow, you can shorten the run by using the lift as early as possible to reduce the weight on the landing gear and thereby cut down ground friction.

Find the best running attitude for each set of conditions. This will usually be with the tail somewhat lower than for normal take-off on a




hard surface. When snow is rough or sticky, it may be a good idea to pull the plane off with the tail well down, and then pick up flying speed by holding a constant altitude. In heavily drifted snow, the pulled take-off is practically essential in order to avoid damage. The airplane will usually be thrown into the air. Naturally, just before it settles back, you will bring the tail down as far as possible without stalling, and hold the plane in the air if speed is sufficient.

These procedures do not apply if an emergency makes it necessary for you to take-off with frost or snow still on the wings. Under these conditions, take off in flying position. Do not make a pulled take-off. Watch your air speed. Do not try to climb too rapidly. There is a good chance that you will stall, abruptly and dangerously. Make wide turns—steep turns with iced wings and tail surfaces are suicide. But remember, *try a take-off with snow or ice on wings only when there is no other choice.*

**WARNING**

*Never take off with de-icers on. They will act as spoilers and seriously disturb the air flow over the wing.*

**Jet Airplanes**

Because of the density of cold air, the thrust of the jets at very low outside air temperatures is greater than usual, and jet airplanes can take off at 98% S. O. P. and still get off a thousand feet sooner than in moderate climates.

Due to thaw conditions, caused either by the ambient temperatures or by preceding jet take-offs, the end of the runway occasionally becomes so icy that it is impossible to run up to full power before starting a take-off roll. This is particularly objectionable in formation take-offs. Releasing the brakes when the leader reaches 80% rpm (or sooner if necessary) and completing the final power and instrument check during the first two or three seconds of the take-off roll has proved to be a fairly satisfactory solution of this problem.

Despite all the precautions taken by ground crew and air crew during maintenance and preflight periods, there can still be windshield icing or frost formation if ground haze is present during the take-off. Be ready to go on instruments at any time during the take-off run and during the time it takes for the windshield to clear up.

In the coastal regions and on the Aleutian Chain, where the humidity is relatively high and the temperature relatively mild, carburetor ice is a potent source of trouble at take-off and immediately afterwards. Idling or taxiing with partial power at low temperature allows the engines and carburetor heating devices to cool. Trying to take full power from the engine results only in coughing and spitting and may contribute to carburetor icing just before take-off. The initial rush of air through the carburetor when take-off power is applied causes

the carburetor temperature to go down rapidly before either the exhaust or oil heat have time to build up, and ice usually forms within thirty seconds after the take-off run starts. See that the engine is thoroughly warm, then open it to full power gradually.

In the extremely cold, dry, interior regions, the dangers of carburetor icing are only slight, but the use of carburetor heat is nevertheless extremely important in order to aid vaporization of fuel and improve carburetor performance. However, take special precautions to maintain carburetor air temperature just below or above the critical icing range of −5° C to 15° C. Be careful, also, to see that it does not go above 40° C—the highest point for safe operation. Excessive carburetor heat is as detrimental as too little. Although the carburetor air temperature is safely within limits with carburetor heat on at the beginning of the take-off run, application of full power will cause the carburetor air temperature to increase rapidly beyond the safe range, with consequent loss of manifold pressure and power. Watch the carburetor air temperature gage and be ready to reduce or shut off the carburetor heat.

After take-off, you may or may not use carburetor heat, depending on the temperature, icing conditions, and your normal operating procedure.

Watch the oil pressure carefully after take-off for possible fluctuation or dropping pressure due to a loss of oil. This may result from a leaking oil cooler, discharge of partially diluted oil from the breather, or failure of the main oil supply to replenish the hopper. In certain airplanes not equipped with late-type oil coolers, an increase in oil temperature during flight may indicate oil congealing in the cooler. Close the cooler shutters to correct this condition and expect an oil temperature rise above the normal allowable. One to three minutes at this high temperature will usually de-congeal the oil cooler. Then open the shutters partially and try to maintain stabilized oil temperatures. Late-type winterized airplanes are equipped with self-thawing oil coolers which do not require the use of shutters at any time.

When you reach flying altitude after taking off from a field covered with snow or sludge, operate the landing gear, flaps, and bomb-bay doors through two or three complete cycles to loosen ice and prevent freezing in the "up" position.

## FLIGHT

Many of the natural hazards continue to cause difficulty after the plane leaves the ground. Visibility continues a problem with a low-lying sun and mist. Carburetor ice remains a problem. Ice may form unexpectedly on the wings and control surfaces. Obviously, you have to be extremely sensitive to your instruments to catch any hint they may give of danger.

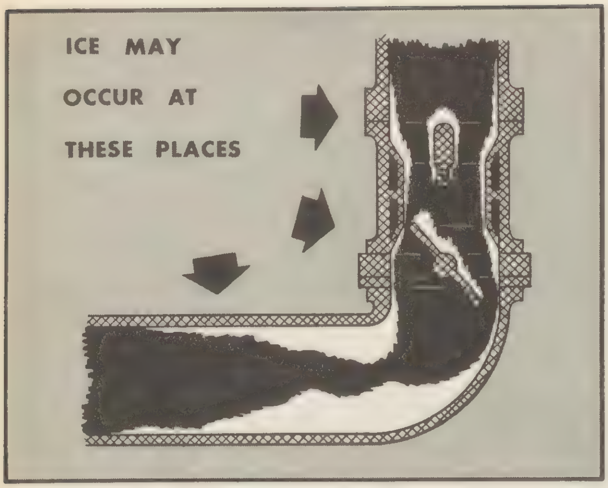
### Instruments

Most of your instruments will be winterized to operate properly at extremely low temperatures. However, use judgment in accepting the readings. Electrically operated automatic pilots will operate satisfactorily down to −65° F with the exception of the C-1 which needs to be maintained above −30° F, but air-hydraulically operated automatic pilots now installed and in stock, have not been tested at low temperatures. Use them with caution. Units at present under procurement have been tested to −30° F and should provide satisfactory operation down to this temperature. If the temperature falls below this, use cabin heat to maintain the temperature of the automatic pilot control units above −30° F.

Electrically driven gyro horizon and directional gyro indicators, types E-1 and C-1, will operate satisfactorily down to −65° F. Air-driven flight and turn indicators (gyro horizons and directional gyros) will operate satisfactorily down to −30° F. (Before take-off, use ground heaters to bring the temperature of these instruments to at least −30° F.)

### Carburetor heat

As previously mentioned, carburetor heat is as important under conditions of extreme cold to aid in fuel vaporization as it is in conditions of high humidity to aid in eliminating carburetor ice. Learn to use carburetor heat effectively in each case. Icing of the induction system occurs in clouds, rain, fog, sleet, wet snow, supersaturated vapor, and high relative humidity. This ice may be of two kinds, atmospheric ice, and fuel evaporation ice. Atmospheric ice is formed from water which originally existed in the atmosphere as snow, sleet, super-cooled moisture, or liquid water hitting surfaces that are colder than 32° F. Fuel evaporation ice is formed by the cooling effect resulting from the evaporation of the fuel in the carburetor air stream. If the moisture content of the air is high, this type of ice can form and has been




*Carburetor icing.*

known to form with free-air temperatures up to 95° F. Icing is most likely to occur when the carburetor air is between −5° C and 15° C.

Develop consciousness of moisture in the air. High moisture content is indicated by large snow flakes. In cold, dry air the snow forms in small, hard particles. Observe the windshield and the propellers. Normally you can detect the formation of ice in the induction system by a gradual loss of rpm with a fixed-pitch propeller. Another sign is a gradual loss of manifold pressure when you do not change the throttle position or the altitude of flight. If you are off guard and assume throttle creep, you might keep advancing your throttle gradually to maintain constant rpm or manifold pressure without realizing that carburetor ice is forming. Be on the alert. Under extreme conditions, ice may form so rapidly as to cause abrupt power loss. Be particularly on guard if your airplane is equipped with an automatic boost control, for there will be no loss in manifold pressure until the icing becomes serious. Check for carburetor icing by applying carburetor heat and noting the effect in the operation of the engine. If the manifold pressure remains the same or decreases slightly and then rises, it indicates carburetor icing.

Prevent carburetor icing by using whatever carburetor heat is necessary, as indicated by conditions. Air intake ramming conditions may require use of the control nearly full on at first, to get adequate heat. After this initial effect, however, a small movement of the heater control will cause a large range of temperature changes. It is good practice to apply carburetor heat for one to two minutes every half hour during flight. Likewise, check constantly to make sure the carburetor air temperature is either above or below the icing range.

When cruising at extremely low temperatures, apply carburetor heat to aid in proper fuel vaporization and distribution, especially at low power settings. In sub-zero temperatures, you can recognize improper distribution by the appearance of yellow exhaust flames accompanied by sooty smoke, usually from only a few cylinders of the engine. The only precaution necessary is to keep carburetor air temperature below 40° C to avoid detonation with consequent loss of power or possible engine failure. The engine often performs smoothly with the carburetor heat control on COLD. Just be careful to keep the carburetor air temperature either below −5° C or above 15° C to avoid icing.

When flying with mixture control in CRUISING LEAN position, apply sufficient heat to maintain the carburetor air temperature above 15° C. When cruising under severe icing conditions, use at least 75% engine power, with the mixture on the rich side of best power unless you encounter exceptionally rough air or need to conserve fuel, in which case, lower the power setting and decrease speed to 50% above stalling speed. Apply carburetor heat to effect full vaporization, but remember that carburetor air temperatures above 40° C may cause the engine to detonate. Therefore apply heat only until the engine operates smoothly.

Where icing has progressed, the air-intake channel is considerably reduced in section. Thus the quantity of air entering the engine is reduced and the mixture becomes rich. Your fuel-air analyzer will indicate this condition. If your mixture becomes rich for no apparent reason, or if the manifold pressure or rpm with a fixed pitch propeller begins to drop, then it is time to put carburetor heat on. There will be a slight loss of power when you first apply heat. If the manifold pressure or rpm continues to drop—change to rich mixture. Do not advance throttle while cruising until you have full heat applied to the carburetor. Act quickly. Ice accumulation is progressive and you may have only a minute or two in which to stop it.

Turning on the carburetor heat causes a slight loss of power (indicated by a drop in manifold pressure) due to the reduced air-intake pressure and the lower density of the warm air. This loss of power involves no sacrifice in engine

efficiency when operating with the carburetor mixture control in the AUTOMATIC position, since an increase in carburetor air temperature will enrich the mixture; you will then have to readjust the manual control whenever you change the carburetor heat control setting.

Carburetor heat is useful in smoothing out rough engines in extreme cold and at low power settings. This is especially true of liquid-cooled engines. Carburetor heat also prevents plug fouling during long-range, low-power missions.

Some airplanes are equipped with an alcohol carburetor de-icing system in addition to the carburetor air heating system. If your airplane is so equipped, turn on the alcohol pump immediately before the take-off when icing conditions are prevalent and place the carburetor heat control in the full cold position. The richer carburetor mixture caused by the alcohol will result in a slight loss in engine power. When you reach a safe altitude, adjust the carburetor air heat as described previously and turn off the alcohol pump. Except in emergencies, do not use the alcohol system in flight. When you do use the alcohol system, remember that the alcohol supply is limited to about one hour of continuous use. Try to adjust the carburetor temperature periodically.

**WARNING**

*Using the alcohol de-icing system at very low power settings and low engine idling speed produces a rich mixture which may choke the engine.*

If your plane is not equipped with an alcohol de-icer and the carburetor air heat does not prevent icing, put the carburetor heat on full cold and lean the mixture until backfiring occurs. The backfire will loosen the ice and blow it clear of the intake passages. Sometimes, you can dislodge ice by closing the throttle. However, both of these procedures are hard on the engine and carburetor mechanism. Use them only in extreme emergencies.

### Ice on Surfaces

Icing is likely to occur on wings, tail surfaces, and propellers in areas of precipitation or clouds when the temperature of the air or airplane surface is less than 36° F. However, ice can form at any temperature below freezing, and has been known to form at temperatures as high as 40° F.

Depending on conditions, ice may take any one of three forms: *clear ice* (*or glaze*), *rime*, *frost*, or a combination of the three. *Clear* ice, or glaze, is a hard, dense ice which forms when the plane is flying through clouds consisting of large moisture droplets, or through a freezing rain. Clear ice is the most dangerous form. It builds out from the leading edge in a mushroom shape that spoils the airfoil and therefore decreases lift. *Rime* is an opaque, whitish ice with a granular texture, formed by small droplets of water. Generally, rime ice does not destroy the shape of the airfoil and can be removed easily from leading edges with pneumatic de-icing boots. Rime, however, does have a tendency to stick just to the rear of the boot. Being rough, rime increases the drag and increases the stalling speed of airplanes with high wing loading. You can easily recognize its initial form when small white buttons of rime appear on the tops of rivet heads. *Frost* consists of small separate ice crystals.

Besides its effect on lift, drag, and stalling speed, surface ice, by its weight, increases the wing loading and displaces the center of gravity of the plane. By preventing the movement of control surfaces, icing causes a loss of control. Try to remedy the situation by escaping from icing conditions, and by turning on the wing and tail de-icers. However, don't turn on the de-icers until the ice is approximately a quarter-inch thick or the boot will create a hollow space in the ice and become ineffective in removing the ice. Try also to leave the region of icing before using the de-icer boot, as there is a tendency for the ice to build up in ridges at the point where the boot ends if it is used for too long a period.

Icing is likely to occur below temperature inversions, along fronts, and over mountains. Temperature inversions, typical along a polar front, are caused by a relatively warm air mass rising above sub-freezing polar air. Moisture falling from the upper warm air through the lower cold air cools to sleet, freezing rain, or snow, and usually forms clear ice. You can often avoid inversion icing by climbing into the warmer air. In warm fronts, the over-running warm air may be above freezing in the lower levels, preventing icing in that region, but the upper portion of the cloud system may be cold enough to cause severe icing. Stay in the lower levels. In cold fronts, the presence of cumuliform clouds and the upward air movements that cause them are likely to cause clear ice formation. Although

the cold front formation is narrower than the warm front, icing is more severe because of the higher rate of accumulation. Icing is most frequent and most dangerous over mountains. Mountain ranges cause upward motion of air capable of supporting large droplets of moisture. With low temperatures, this results in clear ice. You will find the most severe icing above the crest and to the windward side. Avoid turbulent areas. When you run into wet, sticky snow, climb above it to colder temperatures where the snow will not adhere so readily. Fly through an icing area fast.

Handling an iced airplane is essentially a matter of maintaining speed and a low angle of attack. The air-flow will continue to adhere to upper surfaces as long as the angle of attack remains small, but there is generally a very abrupt and complete stall when you increase the angle of attack, as in landing.

#### Other icing

Propeller icing may occur under the same conditions as surface icing. Propeller ice is especially dangerous because it decreases propeller efficiency by altering the blade profile and increasing the blade thickness. When ice is thrown from one or more of the blades, it causes excessive vibration and an unbalanced condition. The ice from the propellers is thrown off with such force that the B-29's on the polar flights must have armor plate on the fuselage opposite the propeller trick to prevent the piercing of the fuselage.

Whenever you must fly during icing conditions, prevent ice formation on propellers, blades, and spinners by using anti-icing solution. To treat the blades, an electric pump, controlled by a rheostat in the pilot's compartment, pumps anti-icer fluid from a supply tank to a slinger ring from which it is distributed to the propeller blades. When you expect icing conditions on a flight, fill this tank before take-off. About two quarts of fluid an hour will be sufficient to keep blades free. Surprisingly enough, the little ports through which this fluid flows sometimes become blocked by ice, making the system inoperative. Check these ports before flight.

Other aids to propeller anti-icing are: alcohol anti-icing by means of rubber feed shoes; anti-icing spinners, usually rubber covered; and anti-icing solutions, applied to the dome, spinner and blade. A heating unit for the leading edge of the propeller blade (a rubber sheathing with an internal electric heating element) is being tested now. Often, you can shake off propeller ice by running the propeller up to a maximum rpm, then back to normal.

The air-speed pitot head also collects ice. This causes false readings of the altimeter and rate-of-climb indicator, as well as the air-speed indicator. You can prevent pitot ice formation by turning on the pitot tube heater. When the possibility of icing exists, keep the pitot heater on constantly.

The electrical heater switch is connected through the airplane ignition system in such a way that the heater is off whenever the ignition switch is off. In case the electrical air-speed heater fails during severe icing conditions, you can use an alternate source of static pressure for the operation of the altimeter and rate-of-climb indicator by turning the static-pressure selector to the ALTERNATE SOURCE position. However, this device generally causes the altimeter to read too high, maybe as far off as eight hundred feet. Do not try an instrument landing when you use the alternate source for static pressure.

Some airplanes are equipped with windshield de-icers. This de-icer system provides perfor-

ated tubes through which de-icer fluid may be supplied to coat the windshield. Fluid is supplied through an electric pump controlled by a rheostat in the pilot's compartment.

Icing often constricts venturi throats, causing improper functioning of air-driven gyro instruments.

If you expect icing, move the throttle frequently to prevent its freezing in one position. It's also good practice to increase the propeller speed about 300 rpm for a minute or two every half hour to insure governing at low temperatures. Return to your cruising rpm as soon as the tachometer indicates that the cycle is complete.

#### Oil pressure

If your engine is equipped with an oil dilution valve and suddenly shows a loss in oil pressure or throws oil out of the breather during flight, have the crew chief check the oil dilution valve upon landing to insure that it is in the CLOSED position and fully seated. If your engines are equipped with an electrically operated valve, try to complete the seating of the valve by momentarily turning the switch on and off. The fuel pressure gage should drop when the switch is on. If dilution causes the loss of oil pressure, satisfactory operation will be resumed when the viscosity of the oil is restored by running the engine and evaporating the gasoline in the oil.

### LANDING

Temperature inversions, in which ground air may be 15° to 30° colder than at altitude, are common in the polar regions. When letting down in cold weather, be careful to keep engines warm during the descent. Increase the drag by lowering the landing gear and the flaps so that you can use sufficient power to keep the engines warm. Also close the cowl flaps and apply carburetor heat during the entire landing operation so that if a sudden acceleration is necessary, heat will be available for fuel vaporization regardless of how low cylinder-head temperatures have dropped. However, should full power be necessary to get into the air or to go around, keep carburetor air temperatures below 40° C and be ready to reduce or shut off carburetor heat. Before making your final approach, make sure that your engines will deliver while you still have plenty of altitude.

It may be desirable to lower wheels and use partial flaps well in advance of the actual approach, in order to check on their correct functioning while sufficient altitude remains for emergency procedure. This also allows use of more engine which, of course, tends to eliminate the probability of carburetor icing. On the downwind leg, pump the brake pedal several times while lowering the landing gear to insure circulation of sluggish fluid.

Close the cowl flaps on prolonged glides or approaches, but open them immediately upon landing.

Crosswind landings on clear ice require good timing and excellent judgment, for you lose maneuverability because of the lack of traction. Compensate for drift before you touch. Use rudders for lateral directional control until you get down to the point where you can't use rudder. Use brakes very sparingly but be careful not to lock the wheels on an icy runway.

Land a heavily iced airplane as you would an overloaded plane. Bring it in at an above normal approach speed, depending on the amount of icing.

**WARNING**

*Do not land with de-icers on. They will act as spoilers and disturb the air flow.*

#### Jet Airplanes

The greater thrust in extremely cold air makes it necessary for jet airplanes in low temperatures to fly a larger pattern, makes the landing faster, and requires more time to reduce speed.

If conditions permit, taxi with sufficient rpm to cut in the generator, as low temperatures decrease battery output.

Park at a 45° angle to the line of jet airplanes so that when you pull out, you won't blow slush and snow on the other airplanes. Also move well forward from the line before starting a turn from it when you pull out.

### POST-FLIGHT

Immediately upon landing, dilute the engine oil in accordance with the applicable technical order. See that the shock struts are cleaned, the oil tank sump and the Y-drain are drained of condensate before it freezes, and that the other post-flight procedures described in Chapter 11 are carried out.

With jet planes, when you expect temperatures below −10° F, purge all JP-1 fuel from the fuel system by introducing the gasoline from the

special tank into the engine for at least two minutes before shutting down. Shut down the engine with the gasoline system in operation.

## HELPFUL HINTS

### Depth perception

According to Rear Admiral Byrd, who has had quite a little experience in such matters, the effect of polar lighting and weather on your depth perception is the greatest hazard you can encounter in polar flying. On newly formed snow, or on a dull day, shadows are not visible. This has an effect somewhat similar to that of glassy water and makes it extremely difficult to judge height after leaving the ground. Pilots have thought themselves at a safe height of hundreds of feet only to find their planes plowing into the snow or dragging a wing, and cracking up. Avoid staring ahead when there is nothing to focus on.

During take-off, try to use some reference point as a substitute for the horizon. Reference points far to the side, such as trees at a distance, familiar knolls, hills, and river banks are often helpful. In fact, any object the size and characteristics of which you know will indicate the approximate surface, although the runway may be entirely blended in milky mist. In any event, always be prepared for instrument take-off procedure or to go on instruments.

Light effects on a dull day or over broad expanses covered by newly fallen snow make landing as difficult as take-off. The tendency under these conditions is to fly into the ground rather than to flatten out high. Make power landings until you are familiar with snow surfaces and afterwards whenever you have any doubt as to the surface. Make a power approach at normal approach speed (unless the plane is loaded with ice) and attempt a tail low landing at minimum speed. If possible, make a pass at the field with power before attempting to land. This will enable you to scrutinize the landing strip. At some fields, evergreen trees are set up along the runways as reference markers to help give perspective.

### Visibility

Visibility is a constant problem in polar flying. From take-off to landing, you must be on the alert to avoid the dangers created by poor visibility.

As was mentioned previously (Page 1-4), there are many kinds of fog in the polar region —coastal fog, polar pack fog, spicule fog, and town fog. In addition, layers of thin mist start as low as one hundred feet. These layers of mist are often present even during the day, for they are not dissipated by the low mid-day sun.

Drifting snow also reduces visibility. Winds of nine to twelve miles per hour raise the snow a few feet off the ground, and the blowing snow obscures surface objects such as rocks and runway markers. This is particularly true where there are no trees to break the wind. Winds of fifteen miles per hour raise snow high enough to obscure buildings. With high winds and low temperatures, you may encounter drifting snow up to a height of three hundred feet. Under these circumstances, vertical visibility is generally good—that is, you can see small objects on the ground if you are directly above them—but horizontal visibility is poor.

### Weather

Beware of "williwaws". Near land masses, and especially in the lee of mountainous islands, there is an area of disturbed air currents, the exact position of which can't be fixed because it depends upon the contours of the land and the strength and direction of the wind. These currents are so strong at times that they are a matter of great concern to aeronautical engineers from the standpoint of structural strength, so they are certainly of concern to you for reasons other than academic. The gusts may exceed one hundred miles per hour and throw your airplane around so roughly that crew members may be knocked unconscious (it's happened) and equipment may be pitched all over the plane. Avoid these current eddies by staying away from sharp cliffs, bluffs, and peaks if possible. Stay on the windward side or, if on the leeward side, as far from the conditions as possible. Keep all safety belts fastened.

Know what you are doing when you enter a cloud formation. If you don't know what's in it, nibble at the edges for turbulence and icing conditions. Once in it you may not come out.

Turbulence, if it is not severe, is more of a discomfort than a hazard. But if turbulence is severe and your plane is heavily loaded, you can get into a lot of trouble, expecially if there is icing as well as turbulence. Be particularly careful in hot, high westerly winds over mountains. In case of turbulence, reduce the air speed to fifty percent above stalling to lessen the strain

on the airplane. Remember, too, that your instrument readings will fluctuate.

Any time there is moisture at temperatures below freezing, icing is likely. If your plane has no de-icing equipment, don't fly under icing conditions. If it has icing equipment, stay out of areas of icing anyway. Should you have to fly in icing conditions, be alert for trouble.

Take into consideration also the effects of various weather conditions on radio transmission and reception. Under certain conditions of precipitation, either rain or snow, radio transmission and reception will go out. Change of altitude, air speed, or propeller speed may help right the trouble, but if you cannot establish radio contact, don't proceed unless you have excellent knowledge of weather conditions ahead.

#### General

By all means, familiarize yourself with the area to be flown and its landmarks, but just because you are familiar with them, don't set yourself up as an old timer. Plenty of rocks look alike, and you could be wrong in identifying one of them. Better orient yourself by at least two landmarks before you act on your supposition that you know where you are.

"Play ball" with your altimeter. The high winds sometimes encountered in the polar regions cause the isobars to be very close together, and as each isobar represents approximately one hundred feet in altimeter setting, failure to get correct setting may cause large errors in altimeter readings. Allow for a big margin of safety. A thousand feet for yourself and five hundred feet for each dependent has been suggested as a good rule.

And finally, don't get too discouraged by all the problems on polar flying. Remember that Sir Hubert Wilkins, the noted explorer, proved as long ago as 1928 that flights above the Arctic Circle are possible with aircraft of low horsepower and little equipment as compared to our modern planes. He flew non-stop from Point Barrow, Alaska to Spitzbergen, Norway, a distance of some 2200 miles. Your plane, your equipment, and your weather information will be far superior to his.

### SKI PLANE OPERATION

#### General

Handling planes equipped with ski-type landing gear requires considerable study and practice. Before a man can be classed as a "ski pilot" he must have a mastery of ski plane technique and a thorough knowledge of ski plane performance. He must be familiar with the effect of wind and of different types of snow, and he must be able, while still in flight, to "read the snow condition" on the ground.

In normal flight, there is practically no difference between ski planes and conventional planes. On the ground, ski planes have several advantages over conventional planes. They can land on snow or ice and, in an emergency, on slush. They can take off or land along a curved or circular course. However, they must be handled with extreme caution on the ground because of their forward and lateral lack of control at low speeds.

#### Taxiing

Taxiing a ski plane in a congested parking area is a very difficult procedure. Have the plane towed in or out by a cletrac or other available vehicle. When you land at remote regions where towing facilities are not available and you have to taxi under close conditions (for

example, near a river bank, a heavily wooded area, or other airplanes), have a rope attached to the wing mooring ring on each wing, have the ropes held by men on the ground, and taxi very slowly. Use this procedure also when taxiing in a strong wind or when you need to turn. Another way to make a slow, sharp turn is to "brake" one ski by placing a small log or two-by-four underneath it.

Because ski landing gear have no brakes, it is often difficult to taxi the plane in moderate to strong winds. Therefore, be very cautious when taxiing downwind or crosswind, as the plane will always have a tendency to "cock" into the wind. Hard-packed snow or glaze ice lets the plane move forward with great ease, while sticky or wet snow retards the plane because of the additional traction. When taxiing on glaze ice, remember that the plane will be difficult to stop and will tend to skid excessively when you make a turn. Skaggs or runners on the bottom of the skis increase the controllability of the plane. Four- to twelve-inch skaggs or runners are installed on most airplane skis. If there are none on the skis of your plane, have them installed.

Making turns while taxiing is a matter of technique in the coordination of power and rudder controls and requires considerable practice. The amount and use of power depends on the wind condition and the extent of turn desired. To make a sharp turn, increase power while the plane is sliding forward, apply full rudder in the desired direction, and as the plane starts to turn, increase power again, then completely retard it. The momentum of the plane will swing it around sharply. To make a wide turn, apply power and rudder simultaneously and maintain them throughout the turn.

#### Take-off

Frequently, skis will freeze to the snow or ice, and you will have great difficulty in "breaking" the plane loose. To free the skis, move the control column fore and aft vigorously, operate the elevators rapidly to produce a rocking motion, coordinate this action with full movement of the rudder control, and apply full power steadily. If this procedure fails, have the crew try to free the skis by prying them loose or digging underneath them. Having the crew rock the wings up and down by alternately pushing and pulling the wing struts while you apply power sometimes helps.

After you increase power, controlling a ski plane on the take-off run is very similar to controlling a conventional plane. As the plane gains speed, you will gain complete rudder control and increased maneuverability, affording you the opportunity of making curved or circular take-offs. The increased maneuverability permits you to start take-off run crosswind, and as the plane gains forward speed, to turn it into the wind for take-off. Try this, however, only if you are an experienced ski pilot. Get the plane into the air as soon as possible in order to avoid having the main skis dig in as they pass over large snow drifts. The condition of the snow will greatly affect the length of the take-off run. Sticky snow will increase the run while dry snow or iced surfaces will permit a very short run.

#### Landing

Always land ski planes in a definite three-point attitude to avoid having the main skis dig in as they make contact with the snow. This is particularly important when landing on crusted snow, sastrugi, or uneven surfaces. Always keep a step ahead of the plane to avoid undesired ground loops. However, if a ground loop is unavoidable, or if you wish to make one, land the plane so that it will not collide with objects near its landing path when it ground loops. If you wish to land along a curved path, maintain power after the plane touches the ground. This will give you maneuverability in the desired direction, but naturally, will increase the distance of the landing roll.

When you land on unfamiliar frozen lakes or on open terrain, pick the smoothest surface, determine the wind direction by observing blowing snow, smoke, or moving grass, and land into the wind. If the landing area is circular and relatively small, start the landing crosswind and complete it into the wind, as mentioned before. However, do not attempt such a landing if you are an inexperienced ski pilot or if the crosswind is very strong.

#### Parking

Do not taxi in congested areas. Do not taxi the skis through oil before parking as this will increase the chances of their freezing fast to the snow or iced surfaces. Placing a one-by-six or similar board under the skis reduces the chances of their freezing. Always moor a ski plane securely, for there is no way to brake the skis if they are not frozen to the surface.

CHAPTER 16

# NAVIGATION

## PROBLEMS

Navigation in the Far North falls into two categories—navigation in the continental areas (as in Alaska and Canada), and navigation in the polar regions proper (as over the ice pack above the 75th parallel). The first type of navigation—that is, in the continental areas—is practically the same as in the States. Of course, changes in variation and longitude are proportionately greater, but anyone competent to navigate in the States can do so in the continental areas of the Far North. In fact, many flights are made daily between such points as Fairbanks and Nome, and Anchorage and Adak, without any navigators at all.

Flight over the polar ice pack, however, is another story. There, because of the difficulties involved in maintaining and measuring courses and doing dead reckoning, you will have to resort to all the tricks of the navigator's trade. While it does not require knowledge of any new principles, it's quite a detailed job, and most polar flights carry three navigators who are kept busy more than 90% of the time performing the great variety of necessary tasks.

One of the navigators maintains DR, keeping up the log and charts. He receives most of his information from the other two navigators, but does his own sighting for celestial. A second navigator watches the scope, making wind runs and obtaining radar fixes. The third navigator is the astro-navigator. He does the computations, sighting, and logging for the astro-compass. To vary the tasks and minimize strain, these navigators switch jobs about every hour. The logging procedure varies with the squadron, but in general, because of the frequent shift in navigators, you must maintain the log with all the precision you used when you were an eager cadet.

### Measuring Courses

Measuring courses in the standard latitudes (0° – 60°) is fairly simple, for the meridians provide ready references for measuring course angles. If you tried the same methods in the higher latitudes, however, you would find that, due to the convergence of the meridians at the Pole, the course would change rapidly. For example, heading east or west at 75° N latitude, the course would change 1° for every 15 nautical miles. At higher latitudes, the change of course would be more rapid. If the course crossed the Pole you would be even more baffled. At the Pole there would be only one direction—South. But which way would not be South?

### Maintaining Course

Maintaining course is not particularly difficult in the lower latitudes. After establishing true course, all you need to do to maintain this course is to apply magnetic variation, compass deviation, and drift (wind) correction to the compass heading.

Maintaining course when flying in the higher latitudes is quite another matter. In the first place, so many and so rapidly changing are the magnetic irregularities that the magnetic compass is practically worthless. In the second place —and this is more important—in polar navigation you are so close to the magnetic reference point (magnetic North Pole) that even if the magnetic field were perfectly regular you still could not use the magnetic compass effectively.

### Dead Reckoning

With the magnetic compass useless, with course direction changing rapidly, with visibility frequently zero, and with landmarks few and far between, it takes complete coordination of all navigational procedures to determine ground speed, drift, and position. Dead reckoning in the polar regions is therefore an involved and arduous task.

## SOLUTION

Obviously, since polar flights are an almost daily occurrence, there are practical answers to all the problems of polar navigation. The two items that are different about the way navigation is handled in the polar regions are the use of a grid system to eliminate the difficulties caused by the convergence of the meridians and the use of the gyro compass as the basic directional instrument in place of the magnetic com-

pass. For the rest, polar navigation requires only thorough planning, careful logging, and efficient utilization of radar and celestial procedures.

### THE "G" SYSTEM

The "G" system is the directional reference system that simplifies high latitude navigation and alleviates its numerous uncertainties. This system has worked effectively for quite a while now in polar navigation.

The grid system substitutes a grid for the meridians and parallels of the aeronautical chart and grid directions for geographic directions. Make the grid by first drawing a line along the 0 and 180th meridians and marking the direction away from the Pole along the 180th meridian as "grid" north. Then draw a series of lines on the chart parallel to this meridian. Consider each of these lines as "grid" north-south lines. Using the same spacing, draw a series of lines perpendicular to the "grid" north-south lines. These will help you in measuring and in celestial. When you finish the grid, your chart will look like the illustration below.

Now compare plotting and logging a flight on a standard chart and on a "grid" chart. Using the standard chart, there is a continual change in the course heading which complicates every factor that has to be taken into consideration in navigation. Using the "grid" chart, the course heading remains constant. Similarly with wind. On the "grid" chart, wind azimuth is always the same as wind direction, and when the wind is constant, wind azimuth is constant. Thus, the "G" system simplifies most of the navigational problems in the polar regions.

### DIRECTIONAL GYRO

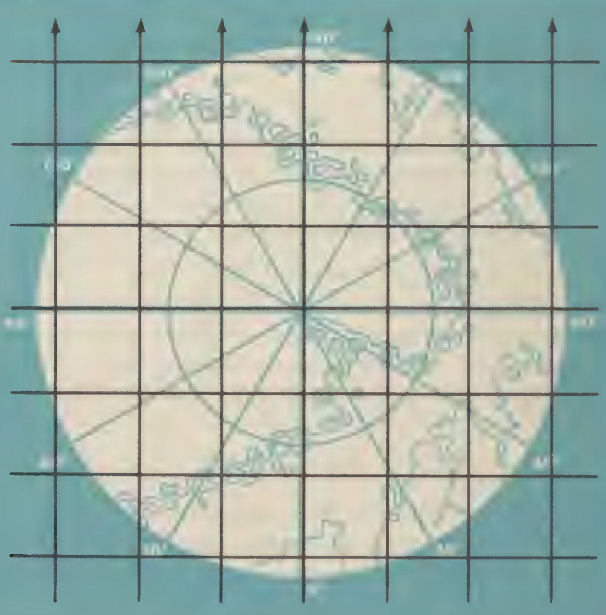
Just as the "G" system helps solve the problem of plotting course in the polar regions, so does the directional gyro help in maintaining courses there. It is not affected by magnetism and is so constructed that, with due correction for precession, it will steer a true line in space. Consequently it is free from the difficulties besetting the magnetic compass and provides a practical instrument for maintaining course in the higher latitudes or polar regions. The most important procedure with reference to the gyro compass is, of course, correction for precession.

The value of this precession rate is not absolutely constant throughout the mission. Instead, it is subject to random fluctuations about a mean value, as well as to a small variation due to changes in latitude. Of the two errors, the random changes are the greater and the more erratic. For gyros now in use, the standard deviation of these random changes over a 10-month observation period is approximately 2°. Thus, you should not take errors of this order to indicate an unreliable gyro.

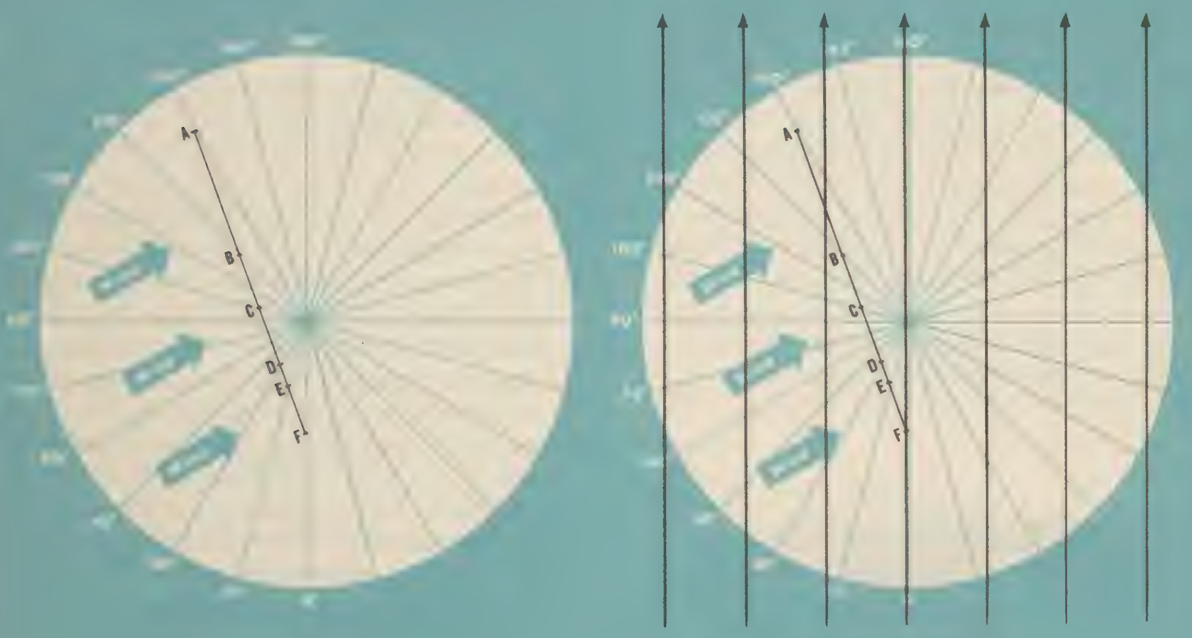
**Convert true direction to "grid" direction as follows:**

**True Direction + West Longitude = "Grid" Direction.**

**True Direction − East Longitude = "Grid" Direction.**



**Compare plotting and logging a flight on a standard chart and on a "grid" chart.**



True Course at A—010°; Wind 090°/10K
True Course at B—025°; Wind 105°/10K
True Course at C—055°; Wind 135°/10K
True Course at D—115°; Wind 195°/10K
True Course at E—145°; Wind 225°/10K
True Course at F—160°; Wind 240°/10K

Grid Course at A—160°; Wind 240°/10K
Grid Course at B—160°; Wind 240°/10K
Grid Course at C—160°; Wind 240°/10K
Grid Course at D—160°; Wind 240°/10K
Grid Course at E—160°; Wind 240°/10K
Grid Course at F—160°; Wind 240°/10K

While better gyros are presently being developed and should be available in the future, it is believed that there will always remain the necessity for accurately logging astro-compass and gyro information for the determination of precession rate. To date no official form has been established for logging astro-compass and gyro performance data, but the squadrons operating in the polar regions have developed their own form of a log and procedure to follow in order to reduce the labor of determining and applying the gyro precession rate and to provide a record of gyro performance which may be used with fair reliability if an overcast prevents further astro-compass checks of heading.

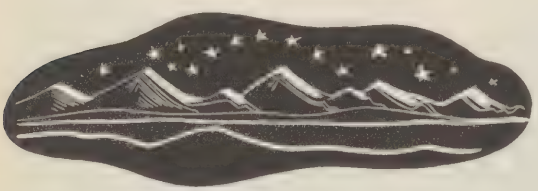
### MISSION PLANNING

Because the areas over which you fly in the polar regions are generally devoid of navigational aids, landmarks, and emergency landing fields—and because of the vast amount of work that must be done by the navigators during flight—it is particularly important that you prepare a thorough and complete plan for each polar mission. In addition to the things you would normally plan for in a flight, you must prepare in advance such things as the azimuth and altitude of good stars. Plan, for example, on the time to switch from using tables to using the Pole as the assumed position in obtaining celestial LOP's. It's a good idea also to plan for meridional altitude shots to save yourself time and trigonometrical solutions.

Above all, plan your flight so that, during twilight, you will not have to take any important celestial shots, such as those involved in a radical change in course, determination of gyro precession, take-off, or approach the home base. Having made your plans, see that you stick to the time schedule closely enough to avoid the necessity for celestial shots during the twilight period.

## DEAD RECKONING

In the polar region, as in any other region, dead reckoning is the foundation of navigation. The big difference in the polar region is the necessity for the continual use of radar and celestial in order to keep DR navigation accurate. Naturally, you must keep a detailed and accurate log in order to derive full benefit from these procedures. Furthermore, since the primary purpose of most flights over the polar regions is reconnaissance, detailed and accurate logs are needed in order to evaluate properly all other records of the flight. Thus, the fact that successful observations or photographs were made during the flight will mean little at the end of the flight unless it is possible to determine accurately the position of the plane at the time of the observation or photograph.



### Celestial

Polar celestial is like celestial anywhere else, in that there are many ways of obtaining an LOP. HO 230, which is similar to the HO 218's here, makes it possible to shoot and solve for as low as 1° of altitude, which is excellent for the polar regions where the sun is at low altitude much of the year. In addition, the American Air Almanac now has polar sky diagrams, which give the approximate altitudes and azimuths of the planets, the moon, and the most important stars. Tables are available to supply plotting corrections for shots when the Pole is the assumed position.

For quick LOP's, meridional altitude shots can be used. Above 80° N you can shoot them when the LHA of the body is within 30° of your meridian, provided the altitude is below 20°. For shots between 20° and 50° altitude, you must choose bodies with an LHA less than 20° from your meridian.

Corrections are about the same as anywhere else, but two types of corrections are quantitatively greater—the correction for refraction (on shots), and the correction for Coriolis force (on LOP's). Be sure to apply them properly.

You need not worry too much about the lack of celestial bodies for observation. Even during the period of daylight, which lasts for six and one-half months out of the year, there are generally one or two bodies available for observation—the sun and the moon—which should give sufficient information for LOP's and steering. The moon is available for approximately two-thirds of the time. Although the sun is visible continuously in the summer, there will be times when its altitude remains very low. During these times you may still use some LOP's provided you apply proper corrections for Coriolis force and atmospheric refraction.

During the three months of continuous twilight (sun not more than 18° below the horizon, yet not visible above the horizon), there is only one good body available for LOP's and steering—the moon—and then it is not present continuously. During this period you may also use the brighter planets for LOP's, but they are difficult to see because of the refracted sunlight. If you are careful you may be able to locate and use the brighter stars, pre-computing the azimuths and altitudes before trying to shoot these bodies. (Daylight sextants will be available soon.)

Total darkness exists for about two and one-half months of the year. During this period, of course, celestial is at its best and a real boon to the navigators.

### Radar

Radar is the chief source of DR information in the polar regions. When undercasts make pilotage and drift readings impossible, or when overcasts prevent celestial shots—and both conditions occur frequently over the ice pack—radar comes to the rescue. It allows you to "see" the ground in the heaviest undercast and, if there are landmarks, enables you to obtain a fix regardless of how much of the sky is covered.

The procedures for using radar in pilotage, wind runs, and fixes on landmarks are, of course, the same as the procedures without radar, except that you observe the scope instead of the ground and that you can see much more on the scope than with the unaided eye. As for fixes based on beacons, radar is simple. A number of X-band radar beacons are already set up in the Far North and more are planned. With these radar beacons you have to receive only one to get a

fix. Giving coded returns for identification purposes, they respond to radar search sets of the APS-10 type as well as to sets like the APQ-13 and APQ-23. The distances at which you can receive them depend on your altitude—their range is the line-of-sight distance. The X- and S-band beacons, together with their location and identification, are listed in CCBP-13, Racon List, which you can get from your Communications or Briefing Officer.

#### Radio

Loran stations are gradually being established throughout the polar regions. A chain of standard-frequency Loran stations centered about the Aleutians, with a range of about 700 miles in the daytime and 1400 miles at night, is already in operation. In addition, three low-frequency Loran stations have been established—near Pt. Barrow, at Victoria Island, and at the mouth of the Mackenzie River. Except along the base line extension, they have a fairly reliable coverage up to 1000 miles of the more distant station of the pair you are receiving. You can receive both the standard-frequency and low-frequency Loran transmissions with either your APN-4 or APN-9 set, provided it includes Coverter CV-27. More Loran stations are being planned, and as the Loran chains are flight checked and become operational they will appear on the Loran charts which you can obtain through the Aeronautical Chart Service.

#### Pilotage

You cannot rely much on pilotage in the polar regions. The maps are constructed from very sketchy data, especially in the interior of land areas. The coast lines, fjords, and river mouths are generally reliable, but mountains are inaccurate in location, shape, and altitude—be careful to clear any possible mountains. Rivers and lakes are generally inaccurate, particularly in the inland area. Terrain features are very scantily sketched, many large areas being described only as "gently rolling land", "tundra", "Arctic waste", or "glacial".

Much of the land in this region is void of distinct landmarks, hampering attempts at pilotage. Although the coast lines may be very accurately charted, extensive areas of fast ice may alter their appearance sufficiently to render them unrecognizable. Such shore ice formations, especially when near snow covered coastal lands, make it extremely difficult to identify the actual shore lines. It is then safer to fly farther inland, where the more prominent terrain features may be revealed.

Visibility is often restricted by low clouds, blowing snow, and fog. Blowing snow seldom reaches altitudes of over 2000 feet, but when it occurs you must resort to means of navigation other than pilotage. Fog generally exists over the coast lines when the wind is blowing in from the sea and over the open sea when the

air mass is cooler than the water. Under these conditions, continue on course, as the fog areas are generally of a local nature.

The polar regions however, are not entirely disadvantageous with respect to pilotage. Pitch darkness is seldom encountered except over large areas of open sea. In the summer, there is abundant daylight with long twilight; in the spring and autumn, there is nearly continuous twilight. Though direct sunlight is absent in these regions in mid-winter, the ground is usually covered with snow, and the refracted light from the atmosphere makes it possible to see dark objects at considerable distances. The moon aids visibility during these periods of darkness so that pilotage, although difficult, is not impossible.

Sky maps are polar phenomena which can be helpful if properly interpreted. A uniform overcast with clouds at a very high level reflects the surrounding terrain. Areas of level ice uniformly covered with snow show up as uniform white on the sky map. Broken surfaces, such as pressure ridges, pack ice, and drifted snow areas are indicated by grayish patches on the sky map. Open water, timber, and snow-free terrain

show up as black areas in the cloud reflection. A careful study of the sky map may frequently help you determine the proper direction to reach open water, snow-free areas, or heavy timber.

You can determine wind direction over snow covered areas by reference to sastrugi. These are ridges of hard-packed snow, a few inches to two or three feet in height, which always develop with an axis parallel to the prevailing wind direction. The sastrugi also give possible reference points for reading drift and checking ground speed by timing. Over open water areas, you can read drift from floating ice, ridges in pack ice, or white caps.

### INSTRUMENTS

No matter how good your methods and careful your computations, they can be no better than your instruments. Take good care of them. Electrically heated flying suits affect direct-reading aircraft compasses principally because of the single-wire direct-current supply on which these suits are operated. Before taking off on a mission on which electrically heated suits will be used, swing the compass with all electric circuits and all suits, except your own, switched on. It is essential that you turn off your suit before reading the compass; turn the rheostat to the OFF position or pull the connector from the extension cord socket. Electrically heated flying suits do not affect remote reading compasses.

Gyro fluxgate compasses now incorporate a low-temperature starting button on the amplifier. When this button is depressed, additional power is supplied so that the gyro will start at extremely low temperatures.

The type A-10 sextant is the only type for low-temperature operation. When properly winterized, this instrument will give excellent results at low temperatures. However, there are two things that you must do in extremely cold weather:

Keep the flashlight batteries warm by carrying them inside your flying suit. Below $-4°$ F, a dry cell will not generate sufficient current to cause a light to glow.

Avoid breathing directly on the surface of the index prism to prevent the formation of ice. If ice or frost forms on the prism, warm the surface with your hand until the ice melts; then very carefully clean the prism with a soft, clean cloth or cleaning tissue. This operation will not be necessary if you use caution and don't let your breath come in direct contact with the prism surface when the instrument is colder than the surrounding air.

A winterized type B-3 driftmeter will operate satisfactorily down to $-65°$ F. Permit the gyro to warm up for thirty minutes after starting before uncaging it. If necessary, you can make drift measurements with the gyro caged. However, you will not have the advantages of gyro stabilization. It's impossible to turn the rheostats on these driftmeters at a temperature of $-45°$ F or lower. So adjust the reticle light to the desired intensity before the airplane is exposed to low temperatures. A low-temperature starting button has been added to the B-3 driftmeter to provide additional power to the gyro for low temperatures.

Most precision watches are unreliable at temperatures below $-40°$ F. Carry your master watch in an inside pocket and refer to it only to check your hack watch. You should have no difficulty with the hack watch as long as you wear it on your wrist. Do not wear the watch outside your clothing or leave it attached to the sextant for periods greater than fifteen minutes.

# PART 5

# SURVIVAL

# PART 5

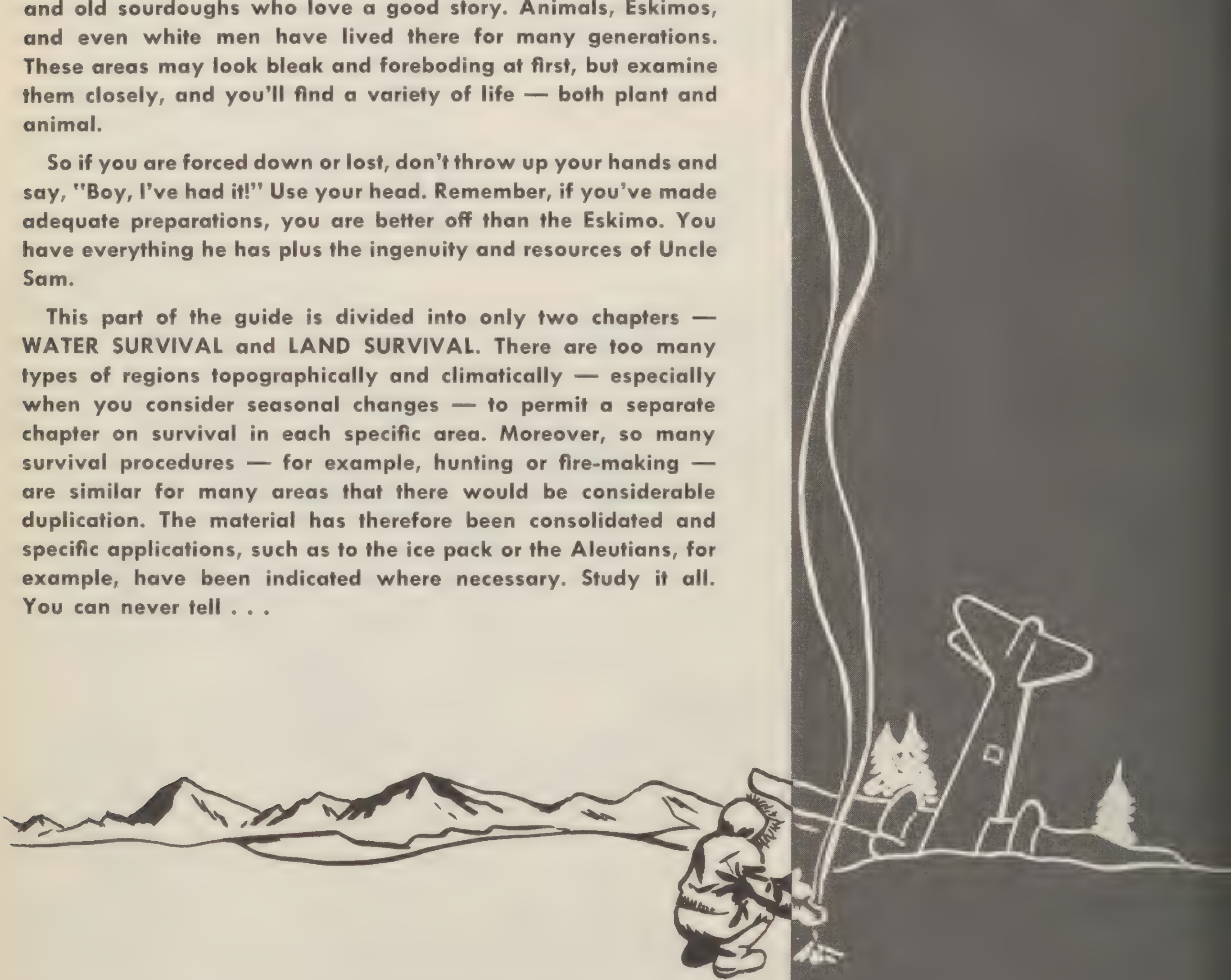
CONTENTS



Contrary to popular belief, the polar regions are not regions of nameless terrors — *if you are prepared for an emergency.* They have acquired their reputation only because of the exaggerated stories of people who were not properly prepared and some explorers and old sourdoughs who love a good story. Animals, Eskimos, and even white men have lived there for many generations. These areas may look bleak and foreboding at first, but examine them closely, and you'll find a variety of life — both plant and animal.

So if you are forced down or lost, don't throw up your hands and say, "Boy, I've had it!" Use your head. Remember, if you've made adequate preparations, you are better off than the Eskimo. You have everything he has plus the ingenuity and resources of Uncle Sam.

This part of the guide is divided into only two chapters — WATER SURVIVAL and LAND SURVIVAL. There are too many types of regions topographically and climatically — especially when you consider seasonal changes — to permit a separate chapter on survival in each specific area. Moreover, so many survival procedures — for example, hunting or fire-making — are similar for many areas that there would be considerable duplication. The material has therefore been consolidated and specific applications, such as to the ice pack or the Aleutians, for example, have been indicated where necessary. Study it all. You can never tell . . .



CHAPTER 17

# WATER SURVIVAL

### BAILING OUT

Bailing out is a very last resort. Don't bail out unless it is absolutely necessary. Should you have to bail out, however, remember that you can survive many hours immersed in polar waters if you wear a properly adjusted anti-exposure suit over adequate cold weather clothing.

The anti-exposure suit is one of your most valuable survival items. Aside from its value in bailing out over water, it is also good to wear while fording streams or digging out snow caves. Put it on over heavy flying clothes as shown in the accompanying illustrations. If time is short, you can put this suit over your life vest. Use care in forcing your hands through the tight wrist bands. Leave some air in the suit for flotation. Keep the air up around your chest as much as possible. Be careful not to tear the suit on sharp objects in the plane. When in water, don't be alarmed by a slight leakage around your face and neck. The suit can take in a gallon or two of water without loss of flotation or insulating functions.

If there are no waterproof gloves in the pockets, wear regular gloves. You can wring them out after boarding the raft, and they will help keep your hands warm and prevent them from getting stiff.

Don't hesitate to put on the anti-exposure suit over wet clothes if necessary. If possible, practice putting it on before making a flight. Without an anti-exposure suit, you may become relatively helpless in twenty to thirty minutes.

1. Open container using zipper or rip tab.
2. Put suit on over clothes.
3. Get both feet in before inserting arms.
4. Push hands through tight wristlets carefully.
5. Adjust hood properly.
6. Squat to expel excess air.
7. Wear Mae-West and parachute over suit.

DONNING ANTI-EXPOSURE SUIT

*Boarding a One-man Raft.*

The sensation of coldness is brief; numbness, stiffness, fatigue, and weakness develop in ten to twenty minutes and make swimming, climbing into life rafts, and other activities difficult. Within thirty to forty minutes a feeling of resignation and comparative comfort ensues, and loss of consciousness may follow. Immersion can probably cause death in thirty to ninety minutes by drowning through loss of consciousness, but with proper flotation gear, such as the B-5 Mae West, you may live longer even though unconscious. Don't be a fatalist and assume that you are good as dead as soon as you hit the water.

If you do bail out, don't inflate the Mae West until you unfasten the chest strap of the parachute. Get out of your parachute harness, avoiding shroud lines. Then inflate at least one half of the Mae West. If there is a brisk wind, you may become entangled in the chute; get upwind and to one side of it. Carry a knife in an outside pocket to cut away entangling shroud lines. Try to save your parachute, though, for it may be helpful later.

## SWIMMING ASHORE

Try to swim ashore only if you are without a life raft. Keep your clothing on—it helps keep you warm. Wear your gloves to keep your hands from getting stiff. If you are wearing an anti-exposure suit or an inflated Mae West, swimming on your back is easiest. Swim leisurely. If you are caught in seaweed, pull yourself through by grasping vegetation. Ride breakers as much as possible unless they are very large, in which case it may be better to deflate your life vest and dive under. Avoid landing at places where waves break against rocks. If rescue by boat or plane is imminent, concentrate on keeping afloat. Don't thrash around in water. Such action only makes you colder. Keep the back of your head and neck out of water as much as possible.

## BOARDING RAFTS

After working free from your parachute and inflating your raft, get out of the water at once. Board a one-man raft from the narrow end. Pull yourself partly onto the raft, face down, kick your feet as in swimming, and then with a sudden upward and forward lunge pull the raft under you. Another method is to pull the raft under you before it is fully inflated. It then rises as inflation is completed.

If possible, board a multi-place raft from the wings or fuselage of your ditched plane, keeping as dry as possible. Don't jump into the raft. When several men are in water, one man should hold down one side of the raft while others climb in singly from opposite sides. Use a rope ladder if available. Without help, the best place to board a raft is over the end with the wind at your back. You can climb aboard more easily if your Mae West is not inflated.

To right a capsized raft, crawl up one side, grab the righting rope, life line, or right handle on other side, and fall backwards into the water pulling the raft on top of you.

## IMMEDIATE ACTION AFTER BOARDING RAFT

If anti-exposure suits are available and you're not wearing one, put one on even over wet clothes.

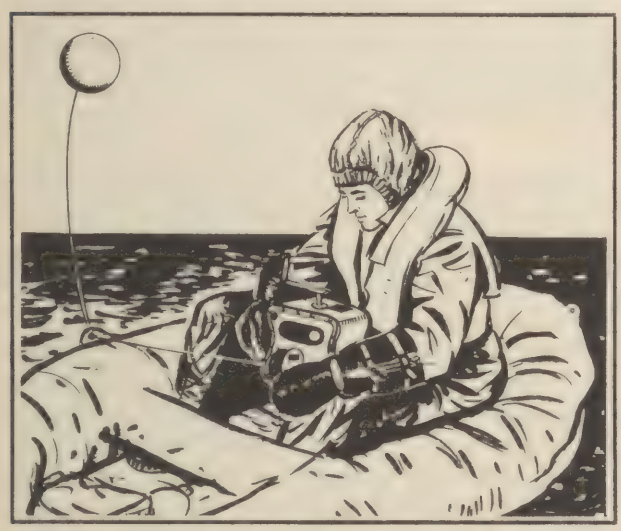
If you have no anti-exposure suit, wring out your clothes and get as dry as possible. Keep the floor of the raft dry. Insulate the bottom of the raft, particularly beneath your buttocks and seat, with a parachute or any other available material. Wrap up in a parachute. Huddle together for warmth. Flex your muscles. If heat tabs and suitable containers, canned heat, or other means of heat are available, make a warm drink. It will be highly beneficial. First Aid is just about the same on a raft as on land. (See page 18-2.)

Search for missing men. Also salvage floating equipment, especially emergency gear, matches, parachutes, clothing, and maps. Keep the raft inflated and plug all leaks. Tie all items securely to the raft to prevent loss if it capsizes. Put compass, watches, matches and lighters in a waterproof container. If there are two or more rafts,

connect them with at least twenty-five feet of line.

If land is close by, head for it at once. Strong tides and currents make it difficult to handle rafts near the Aleutian Islands. Therefore, to prevent the raft from being swept away from the Chain into the Bering Sea or Pacific Ocean, make every effort to reach the nearest land immediately, regardless of the condition of the island.

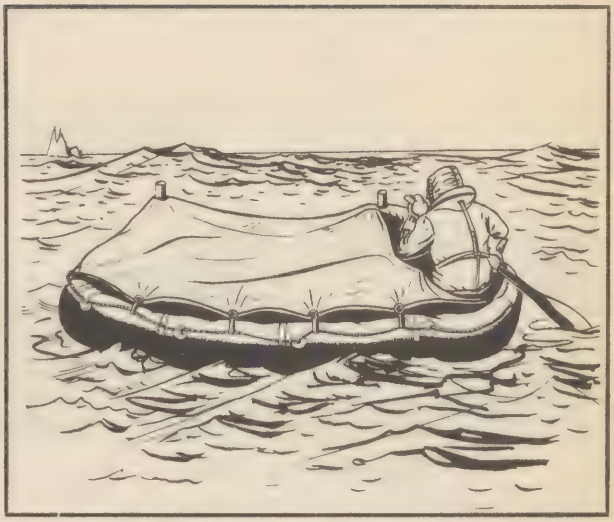
If land is not accessible, stay clear of the plane but in its vicinity until it sinks. Use all possible signaling devices. (See page 18-3.) In a raft, of course, the only way to use the Gibson Girl antenna is with the kite or balloon. Be sure, also, to use the radar corner reflector. It is particularly effective over water. Don't forget your visual signaling devices, either. On the other hand, don't waste flares, sea markers, or grenades—use them only when you sight an airplane or a vessel, and the chances of being seen are good.



*Use the Gibson Girl.*

## PROTECTION FROM EXPOSURE

Your big problem on a raft is protection from exposure. Even if you are wearing an anti-exposure suit, it is a good idea to put up the canopy unless the sea is calm and the weather mild. To erect the canopy on a multi-place raft, shift the oar-locks to six or eight inches from the handles of the oars. Insert this end of the oars through the reinforced holes in the canopy, and place the paddle end in the rubber boat on the floor of the raft. Snap shut the fasteners at the top, close the ends of the canopy by drawstrings, and tie them to the oars. When weather permits, an observer may sit at one end looking out, as illustrated. If the oars have been lost, the canopy can be drawn over the shoulders of the crew members. When the weather is good, you can roll the canopy down.

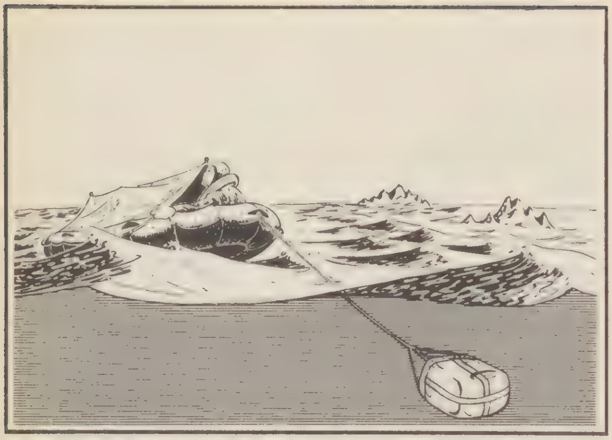


*Protect Yourself from Exposure.*

If the raft is not provided with a canopy, improvise one from a paulin, yellow side up. Tighten the life line around the raft and then tie the paulin firmly to the edges of the raft. For poles, use oars with one section of the handle removed. Use oar locks to help hold the poles in place. To prevent ripping of the paulin, use elastic cord from a parachute pack for ties at points of greatest stress.

## SEAMANSHIP IN ROUGH SEA

In rough weather, put out a sea anchor on a line long enough to permit the anchor to be in the trough of a wave when the raft is on the crest. It may be necessary to improvise a larger or additional anchor from pilot chute, a Gibson Girl pack with holes cut in the bottom, parachute cloth, or other fabric. Improvise a shock absorber on the sea-anchor line to keep it from tearing off the raft. Use three or more elastic cords from the parachute pack as shown in the illustration on the next page, and make a loop of elastic cords. All men should remain seated. Distribute the weight to hold the weather side down. If temperature and wind permit, post a watch to guide the raft into waves and aid in weathering the swells. Each man should keep tied to the raft with approximately a ten-foot line so that the raft won't drift away if it capsizes. Have knives readily accessible to slit the cover if the raft turns over.



*Improvised Sea Anchor.*

## TRAVEL BY RAFT

The movement of a raft can be controlled partly by sail, sea anchor, tiller, oars, and paddles. Try to sail or drift toward land or into well-traveled air or sea lanes. To make best use of wind, rig a sail and inflate the raft fully. Be on watch for strong gusts and arrange the sail so it can be collapsed or turned edgewise into wind to prevent capsizing. To travel by currents, put out seat anchor and deflate the raft so it rides low, but not low enough to ship water. If rescue by an amphibious plane is in prospect, maneuver into the calmest water available, and drift down to plane or boat from windward side unless directed otherwise.

## FOOD

Experience indicates that little drinking water is needed afloat on the cold northern waters. However, dew, rain, or snow can be caught on the paulin or other fabrics. Food will help maintain your strength and resistance to cold. Don't ration it too severely. Fish and birds are your only reliable native foods on a raft. Fish as much as possible. Keep bait or lures moving. Fish at different depths. Birds can be shot or sometimes caught on a baited hook dragged across water. Save fish and bird intestines for bait.

One of the best sources of food in polar waters is *plankton*—a conglomerate of minute sea animals, fishes, and plants which abound in polar waters. Whales and other Arctic animals, including birds, depend to a great extent on plankton for food, and laboratory tests have shown that it is high in nutritive value.

You can readily gather up plankton by dragging a conical net through the water. If you don't have a plankton net, you can improvise one from the upper part of a parachute canopy. Cut out the top to form a cone about three feet long. Tie the vent shut with the string and make a ring about 2½ or 3 feet in diameter to hold the mouth open. Then tie a bridle to it and drag it through the water. Be patient. It will take quite a bit of dragging to secure a substantial amount of plankton. The best way to prepare plankton is to boil it and make a soup of it. But you can also eat it raw. The only disadvantage will be that, when raw, the tiny shells will stick in your teeth.

## CARE OF PERSONNEL

Sea sickness may be relieved by lying down. Do not eat or drink while sick. Lack of bowel movements is normal on rafts—don't be disturbed by it. Likewise the dark color of urine and difficulty in passing it are normal—don't get worried. To prevent immersion foot, keep your feet as dry and warm as possible. Massage and exercise. Elevate your feet and legs for half-hour periods several times a day.

## GETTING ASHORE

Dangerous tides, rips, whirls, and boils occur in narrow passes between islands; avoid them if possible. Surf is heavy on exposed shores; calmer water lies at heads of bays and coves, and in lee of islands and projecting points.

Going ashore in heavy surf is dangerous. Take your time, plan your approach. Lash down all equipment. Open the canopy cover but keep it draped over your shoulders. Keep anti-exposure suits and clothes on. Adjust and inflate your Mae Wests. Trail the sea anchor over stern on a long line. At least one man should face seaward to warn of approaching waves. Don't let the raft get broadside to waves; control it with the rudder oar. Watch for offshore rocks. If the raft capsizes in the surf, try to fall out on the seaward side and grab hold so it can pull you toward shore.

Upon reaching shore, don't assume that your troubles are over. A big task still lies before you —the task of surviving on land—unless, of course, you have landed near a village or inhabited area. (For instructions on land survival, see Chapter 18.)

CHAPTER 18

# LAND SURVIVAL

## FORCED LANDING

Stay on your pre-arranged flight course at all times, so that if you are forced down the rescue party will be able to find you. Keep in touch with the nearest air base; if you find yourself in trouble, you can radio your position before landing. In mid-winter, ice on quiet polar waters attains a thickness of three to six feet. Frozen lakes are therefore the most suitable landing places, although broad rivers, treeless valley floors, beaches, and even ice floes may have to serve. In the early fall, lake landings are inadvisable; and in the spring, beware of rough, discolored, rotten-looking ice. If you are obliged to land on a glacier, ice cap, or on the snow-covered tundra, come down parallel with, rather than at right angles to, the "sastrugi" (wind-formed ridges of snow). If crevasses are visible on your landing area, take them at right angles.

Unless you know the terrain perfectly and have been there a very short time previously, don't make a wheels down emergency landing regardless of how smooth the surface looks. With wheels down, hummocks or piled snow will probably cause you to nose over.

*Don't bail out* unless the plane is afire and in danger of disintegrating. Even in a fighter, your chances for continued life are far greater in almost any kind of forced landing than in a bail-out at very low temperatures with only the small amount of survival equipment you can carry on your back.

In the first place, bailing out is a dangerous procedure in most polar areas. You are likely to be dragged by the wind, your clothes torn, and your body frozen before you can get loose from the parachute. And it can happen even to experts. In fact, it did. In a recent rescue, a man familiar with cold weather techniques, with plenty of parachuting experience, dropped under favorable conditions, was dragged several miles by the wind and was found frozen to death, still in his parachute harness but with his clothes ripped wide open.

Furthermore, your chances of survival and of being found are far, far greater if you stay with your plane. A recent B-29 accident is a case in point. The plane had crashed into a hillside that looked like a cloud, and a good part of the plane had been destroyed. None were seriously injured, however, and the pilot (who should have known better, for he was a veteran of two previous crashes) and the navigator took most of the remaining survival equipment and tried to walk out. The rest of the crew stayed with the airplane and though they had practically no equipment or food managed to survive for five days when they were found and rescued. The pilot and navigator were found shortly afterward, frozen to death, a few miles from the plane.

By crash landing you will have the advantage of a radio, extra emergency kits, and the plane itself, which will furnish material for both shelter and improvised equipment. When you crash-land, get out of the plane as quickly as possible; take your chutes and emergency equipment along if you can do so in a hurry. Simple tools, such as screw drivers, pliers, and hammers can also save you much unnecessary discomfort. Stay away from the plane until engines have cooled, free gas has evaporated, and the danger of fire is past. If you are in a pursuit or a light bomber, keep your chute on as you get out. In large aircraft throw out a few chutes, but don't allow this action to slow up the exit.

## BAILING OUT

Don't bail out unless it's absolutely necessary. If you have to bail out, do these things:

1. Wear the heaviest clothing possible—you'll need all of it. The outdoor air may be so cold that you will freeze parts of your face or hands during descent. Wear gloves and protect your face with your hands if you can. Your rate of descent may produce a freezing effect sufficient to cause frostbite.

2. As you come down, keep your eye on the plane and try to fix the position of the crash so you can get to it after you land. Even if the

plane burns after the crash, the wreckage will still furnish some valuable aids for camping and traveling. Also make a search within a radius of a hundered yards of the crash for things that were thrown out of the plane as it crashed.

3. Don't abandon your parachute after it has brought you down. Every part of it will make useful emergency equipment. In the pocket of each parachute pack is a small booklet on "Emergency Uses of the Parachute", AF Manual 64-0-4.

### PLANNING

Survival procedures naturally vary with the size of the crew. In an emergency landing a large crew is at an advantage, for there can be division of labor according to the skills of the individual members of the crew and, as a result of this teamwork, greater safety and comfort can be achieved. For maximum efficiency, therefore, crews must be carefully trained so that, while all members of the crew are familiar with the overall survival procedures, each member is particularly prepared for one or more special jobs. Of course, there is always a possibility of casualties, and there may have to be substitution of duties. The airplane commander must therefore be familiar with the special skills of each crew member and be ready in case of a crash to assign primary responsibilities for major functions to particular individuals or groups of individuals. In this way all the work involved in survival can be accomplished without neglect of any job because of casualties.

Small crews and fighter pilots must also have a fairly accurate conception of the jobs that must be done in order to survive after a crash landing or bail-out. Regardless of the amount of planning and briefing before the flight, each survival situation has its own peculiarities, and procedures must be planned carefully in order to take best advantage of all favorable factors. Consequently, after giving first aid and doing what you can to keep temporarily warm and dry, plan carefully the survival measures to be taken. Taking into consideration the equipment and supplies available, plan steps necessary for transmitting distress signals, securing shelter, and supplementing your rations.

### FIRST AID

Check for injuries at once and treat them immediately. Keep all injured personnel warm and lying down. Wounded persons require special care because they are more likely to freeze than uninjured men. They must be made warm at once with coats, parkas, chemical thermo pads—whatever is available—even while essential first aid is in progress. When a sleeping bag is used, brush the snow from the injured person's clothing before putting him into it. Watch especially for shock; if not treated at once, it may result in quick death. Shock symptoms are: pale face and lips, clammy skin, nausea, weak pulse, rapid breathing, and mental confusion. Treat a victim of shock by laying him on his back with his head low and his feet raised. It you have no sleeping bag, lay him on seat cushions or floor mats retrieved from the plane. Keep the patient warm, wrapping him in extra clothing or a parachute. If he is conscious, and no internal injuries are indicated, give him warm, sweet drinks, but avoid alcohol. When stopping bleeding, release pressure frequently or the casualty will freeze. If a tourniquet must be applied, warm those parts of the body where circulation is cut off. As soon as bleeding is checked, remove the victim to a warm spot.

Remove boots from injured persons who can't walk and wrap their feet in any covers available. Check the condition of the feet at least twice daily. If feet remain cold for long periods, trench foot or freezing may set in. One such injured man lost both feet because no one bothered to remove his boots during a rescue period of nine days. Remember that the cold pain sensation may be gone entirely when trench foot or freezing sets in.

Treat other injuries as follows:

CESSATION OF BREATHING. Apply artificial respiration with the victim's tongue pulled forward. Check for a fractured skull (indicated by enlarged pupils, bleeding from ear or into skin around eye); keep the victim warm and dry.

FRACTURES. Improvise splints and pad with soft materials; don't remove clothing from fractured limbs, but if a wound exists, cut away the clothing around the wound and dress the wound before applying splints.

### UTILIZING THE AIRPLANE

In all your plans, remember that the plane will provide you with much needed shelter and equipment and will make it easier for the seachers to find you. Don't abandon your plane.

When you are sure that there is no danger of fire, return to the airplane and drain all the oil from the engine. You can do this best by using

the "Y" drain of each engine. Don't worry about containers; at low temperatures the oil will congeal rapidly when draining directly on the ice and snow and in this congealed form can be used at any time for several purposes. However, if you wait long before attempting to drain, the oil will congeal in the engine and you will have to expend a great deal of effort to get even a small amount of oil from the engine. Don't drain the gasoline. Since it will not congeal, the tanks offer the best storage spot for it. You can get the gasoline from the tanks as you need it.

Moor your plane securely so that it will remain in place even if there is a gale. Follow the directions on page 11-5.

## SIGNAL DEVICES AND SIGNALS

If the radio transmitter in your plane is operative, get your radio signals going as soon as possible after giving first aid and taking care of other immediate necessities.

### Radio Signals

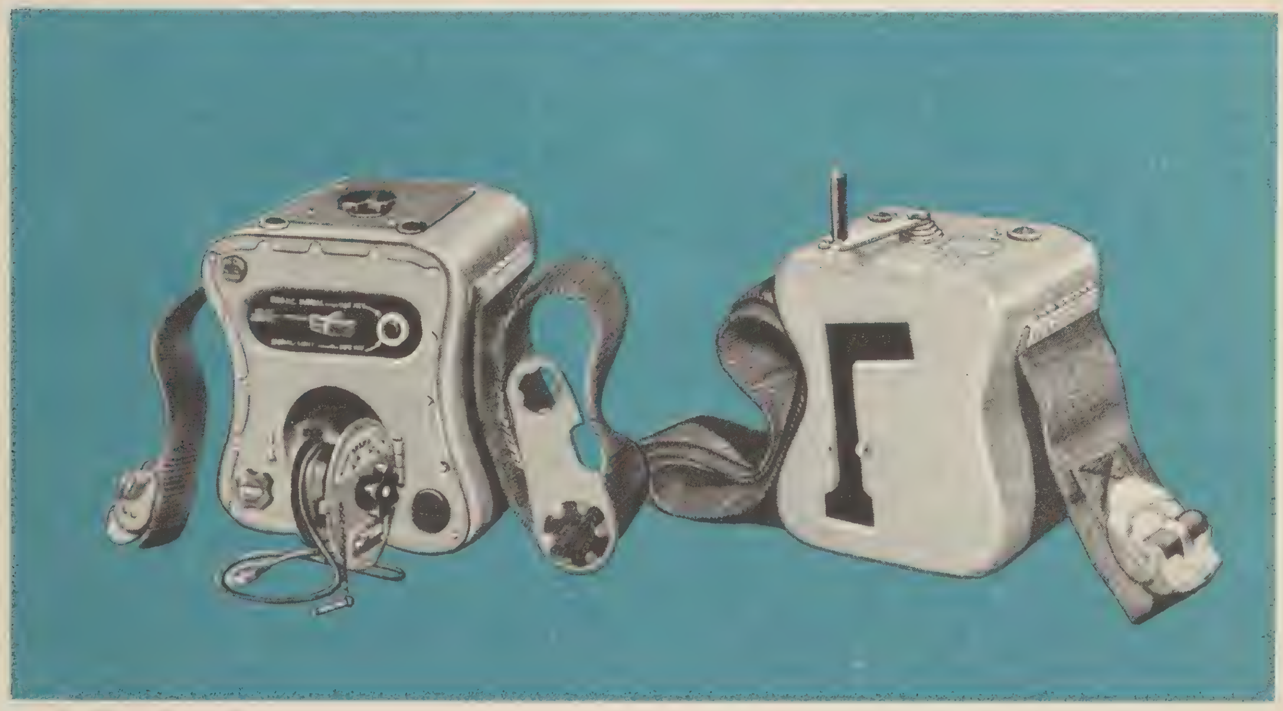
Radio is your quickest and most effective means of securing help. Try to establish radio contact as soon as you can safely return to the plane, and keep on trying. On bombers or cargo planes, use the auxiliary power unit if possible.

Try to start the axuliary power unit by means of its associated battery. If warming is necessary, remove the oil drip pan from under the APU, insert into the pan wicks of harness soaked in gasoline, and ignite them. Keep all available fire extinguishers near for immediate use if necessary. If the APU battery is low, re-charge it on the first running, then cut off the APU.

Since it will obviously be impossible to run the APU continuously, you'll have to determine how often you should start it and how long you should run it. Base this decision on the fuel and oil reserves, the condition of the battery, and the temperature. The interval between periods of running must never be so great that the APU cools below its minimum starting temperature. In general, at an average temperature of $-30°$ F, the unit must be run approximately every one-half hour in order to keep it warm enough to start at will. If you cover the APU with some insulating material, such as a blanket, you can increase the interval between running periods.

If the APU is damaged or if there is none on the plane, use the plane's battery. (In some instances, pilots forced down on ice have used the plane's engine for power purposes by chopping a trough so that the propeller might rotate freely.)

If the regular radio equipment is operative, transmit on the control frequency. Give your identification, assumed position, weather, nature of injuries, and any other information that might aid a rescue party. Transmit during the 3-minute International Silent Period which begins at 15 and 45 minutes after each hour.



*Using AN/CRT-3.*

If the radio equipment is inoperative or if the battery is down, try to attract attention with an emergency transmitter—the Gibson Girl (AN/CRT-3) or the lightweight Hand Energized Radio Beacon Transmitter (AN/CRN-16) which is being developed and will probably be ready for distribution before long.

AN/CRT-3. Set up the Gibson Girl transmitter in a broad valley near a river if possible. Avoid very narrow valleys surrounded by high mountains. If the terrain does not afford a reasonably broad valley, try to gain access to a summit. The best coverage is secured by using all 300 feet of antenna wire supported by the balloon or box kite. When there is less than a seven-mile wind and you can get water for the balloon's hydrogen generator, use the balloon to raise the antenna. You will need four to five gallons of water for the hydrogen generator, and, if water is not at hand (as in an unfrozen stream or lake), you'll have to melt ice or snow to get it. On the polar pack, it may be easier to go to the nearest lead or dig through the floe. To inflate the balloon, follow the directions given on the can in which the balloon is packed.

When the wind is strong, use the kite to raise the antenna. Attach the antenna to the proper tab on the kite. This will keep the kite from jerking violently and perhaps snapping the antenna wire. If you can't use the kite or the balloon, make the antenna as long as possible. Attach the far end of the antenna to a high tree or, if none is available, to the highest point of the crashed plane. To provide a satisfactory means of throwing the antenna to the top of a tall tree, tie the ground wire cap to the end of the antenna wire. Make the antenna fairly taut. Be careful to insulate the end of the antenna from the point of attachment to the airplane structure or tree. Attaching a length of rope, cord, or parachute shroud line is sufficient to maintain clearance of the antenna wire from the grounded objects and accomplish the required insulation.

To get a good ground connection, immerse the ground wire in an open stream or through ice into a body of water. If it is not possible to obtain a good ground, use a counterpoise. Lay out the spare roll of antenna wire in a straight line on the ground and connect it to the ground wire on the transmitter.

If you can't find a high point to which to attach the antenna, lay out the full length of antenna wire on top of the deepest snow or ice bank you can find. For a counterpoise, stretch out the spare roll of antenna wire in the opposite direction from the antenna and connect it to the ground connection at the transmitter.

When you have completed setting up the antenna and ground (or counterpoise), transmit in accordance with the instructions printed on the transmitter. Turn the selector switch to 500 KC/8280 KC AUTOMATIC. This sends an SOS when the crank is rotated. Between sunrise and sunset (or at corresponding times in winter), operate from 15 to 30 minutes after each hour. This will include one of the international distress listening periods. If you can't stand fifteen minutes of cranking, transmit for five minutes, from 15 to 20 minutes after each hour. Be sure to crank a few minutes each daylight hour to make sure the signal reaches distant RDF stations. It will probably take the entire daylight period for the RDF stations to obtain a fix. You can expect search planes on the second day of operation. When you hear or sight them, turn the switch to 500 KC MANUAL. Hold down the key and crank continuously. If visibility is poor when the planes fly overhead, turn the selector switch to SIGNAL LIGHT POSITION and crank. At the same time blink the light with the key.

AN/CRN-16. Development of a hand-energized radio beacon transmitter is now reaching the final stage, and a limited number of these transmitters will soon be available for distribution. The transmitter, which weighs a total of only 2¼ pounds, includes a hand-cranked

generator and can be carried in a pocket of the flying clothes. The transmitter operates at a very high frequency and can be received over line-of-sight distances. It will be particularly useful for fighter pilots.

**Visual Signals**

In wooded country, light a fire at once; it is not only a good signal, but a source of warmth as well. At night it shows up best when inside a paratepee. Don't keep it up all night, though, unless someone can stay up and make sure it stays under control.

To attract the attention of a search airplane after you hear or see one, prepare the materials for a number of flash fires. Use fine slivers of wood from the airplane floor, raveled parachutes and harness, small chunks of rubber from seats and padding, and any other materials that will burn easily. Lay them on some suitable surface (such as a cowl section), which will keep the materials out of the water resulting from the heat of the fire. Include a can of gasoline and water-resistant matches in the cache so that, when necessary, you will be able to start the fire without delay. Cover these materials with a piece of parachute canopy or similar cover to protect them from drifting snow.

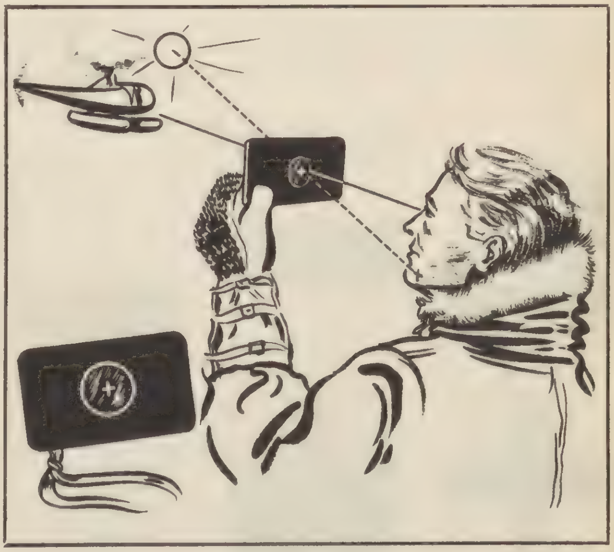
In winter these fires may not be visible from a distance from the air, especially against the snow background. A column of black smoke, however, is a good signal anytime of the year. Therefore, prepare such materials as chunks of congealed oil, animal fat, innertubes, rubber hose, floor mats, de-icer boots, damp leaf mold, green leaves, or rotted wood, to throw on the fire after it is burning strong.

In timber country, both summer and winter, every green spruce tree of good height from about ten feet up is a potential day or night signal of excellent visibility. Gather the dry dead twigs from other trees and shake them free of snow and frost. Then, after you have shaken the tree free of snow, build a big "bird's nest" of them in the lowest branches of the tree you have selected for the signal. When you light the "bird's nest", the tree will go up like a Roman candle. Gasoline thrown on the "nest" or oil-soaked rags placed in it make for really quick starting. You cannot make a better signal day or night. The smoke and flame are visible for miles. If you are lucky enough to be in timbered terrain, don't confine yourself to one tree. Prepare a number of trees, as high as you can on ridges and hilltops, and ignite them whenever you hear or see a rescue plane in the vicinity.

A signal mirror is an extremely effective visual signal. Rescue planes have been brought in by it from distances as great as twenty miles. Keep a signal mirror handy on your person so you can use it the minute you spot a plane. Practice signaling with it. If you have no mirror, improvise one from a ration tin by punching a hole in the center of the lid.

If there is snow, tramp out a big SOS, making the letters about 200 feet high and outlining them with evergreen boughs. A circle stamped out on the snow, laid out with twigs or shown clearly in any other way, is also a clear signal of distress. In open snow country, long straight tracks can be seen from the air for several miles. Take hikes off in various directions, dragging an object that will make good tracks. Keep your plane free of snow so that it will contrast with the snow around it.

Put yellow or orange ponchos or orange-colored life-preserver cushions on the wings. Lay out shiny metal portions, such as engine cowlings, so they will reflect light; arrange several such panels in different positions to create a series of reflected rays with wide coverage. Another good visual signalling device will be your parachute. All new parachutes will be colored international orange, a color which has been decided upon as among the most conspicuous in any kind of terrain. Your Barren Land Tent, if you have one, will also serve as a good visual signal, since it has a fluorescent neon-red color.



*Signal Mirror.*

## GROUND/AIR EMERGENCY CODE

Lay out these symbols by using strips of fabric or parachutes, pieces of wood, stones, or any other available material.

Endeavor to provide as big a color contrast as possible between the material used for the symbols and the background against which the symbols are exposed.

Symbols should be at least 8 feet in height or larger, if possible. Be careful to lay out symbols exactly as depicted to avoid confusion with other symbols.

In addition to using these symbols, make every effort to attract attention by means of radio, flares, smoke, or other available means.

### Acknowledgment

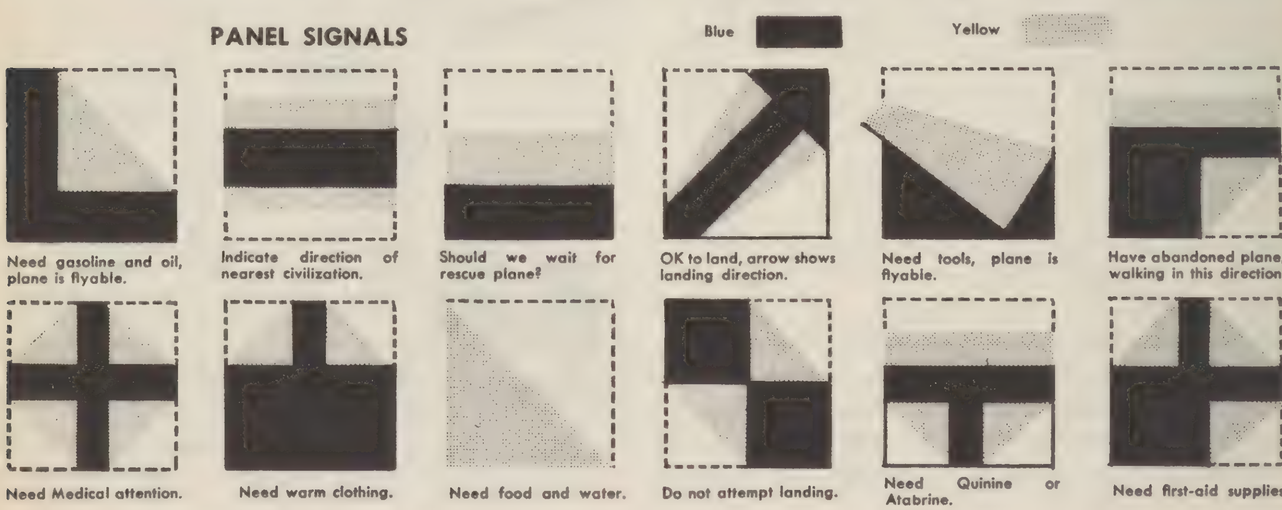
MESSAGE RECEIVED AND UNDERSTOOD. An airplane will indicate that ground signals have been seen and understood by rocking from side to side, or making green flashes on signaling lamp.

MESSAGE NOT UNDERSTOOD. An airplane will indicate that ground signals are not understood by making a complete right-hand circuit, or making red flashes on signaling lamp.

| No. | Meaning | Symbol |
|---|---|---|
| 1 | Require doctor. Serious injuries. | I |
| 2 | Require medical supplies. | II |
| 3 | Unable to proceed. | X |
| 4 | Require food and water. | F |
| 5 | Require firearms and ammunition. | ≚ |
| 6 | Require map and compass. | □ |
| 7 | Require signal lamp with battery, and radio. | ¦ |
| 8 | Indicate direction to proceed. | K |
| 9 | Am proceeding in this direction. | ↑ |

| No. | Meaning | Symbol |
|---|---|---|
| 10 | Will attempt take-off. | I> |
| 11 | Aircraft seriously damaged. | L⅂ |
| 12 | Probably safe to land here. | Δ |
| 13 | Require fuel and oil. | L |
| 14 | All well. | LL |
| 15 | No. | N |
| 16 | Yes. | Y |
| 17 | Not understood. | JL |
| 18 | Require engineer. | W |

### PANEL SIGNALS



In open country spread your signal panel on the ground, folded properly to give your message. Anchor it with a few stones or small logs. In timbered country, fly it from a long pole lashed to the top of the tallest tree. If you have no panel, make signal flags from chute cloth. You can also raise the Gibson Girl balloon or kite antenna above the trees as a signal. On snow or on open water leads within the sea ice, sea marker from your life raft is an effective visual signal; keep it from freezing so that you can use it when you see a plane.

At night or during periods of poor visibility, use colored flares when you hear an airplane. Keep your flares and smoke bombs handy for instant use; don't waste them. Signal with a flashlight or the blinker signaling light of the emergency radio. If the airplane's landing lights are intact and you can get an engine to run, remove the lights and extend them for signaling. But don't waste the battery; save it for the radio.

#### Radar Devices

Corner reflectors MX-137A and MX-138A (Emily) can help greatly in attracting radar-equipped planes to your position. They reflect a large portion of the radar energy that strikes them and make radar detection much more likely. In using a corner reflector, remember that it is a line-of-sight device—that is, objects in the way, such as heavy woods or mountains, prevent signals from getting out. Place your corner reflector as much in the clear and as high as conditions permit. On a smooth, unbroken expanse of ice several miles in area, corner reflectors have a range of two to twelve miles. They require no power and are continuously usable. Just make sure that the reflecting surfaces are always taut and at exact right angles. If the reflector is damaged, try to restore it to its original shape and its original position on the mast.

#### Position Determination

To speed rescue, it is essential that as accurate a position indication as possible be transmitted. You must therefore take precautions to protect navigation instruments, particularly octants and watches, from damage at time of the landing and must remove them, together with map kits, solution tables, etc., from the airplane as soon as possible after landing.

Make observations immediately and from time to time to determine with as high degree of accuracy as possible the position report to transmit over the radio. If, because of loss or damage, no octant is available, improvise some method of measuring altitudes. Use the astrocompass, a Weems Plotter with a plumb line attached at the center of the protractor, or measure the length of a shadow cast by a vertical rod of known height. Crude instruments will give divergent results, but if you average the various positions obtained or send them all, you can help search parties cut down the search area and thereby increase the chances of a successful search.

### SANITATION

To prevent pollution of the living area and of snow and ice which you might use later for drinking water, select a special site for a latrine as soon as possible after landing and establish a sheltered latrine. Adhere strictly to latrine discipline, for you can never be certain that you will not have to occupy your camp for a considerable time even after its position is known on the outside.

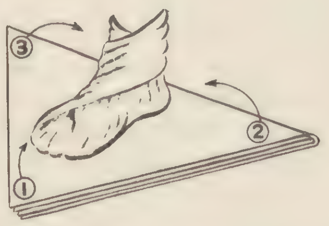
In order to avoid interrupting sleep and having to crawl out of the sack, drink most of your liquids immediately after arising. Don't drink before going to sleep. Besides making for greater comfort, this practice will reduce tendencies toward violation of latrine discipline.

In case the necessity arises while you are on a hunting trip or away from camp for any other reason, don't be afraid of performing latrine duties regardless of the temperature. You have sufficient body heat to prevent the freezing of the necessarily exposed parts during the short period involved. Of course, you should take advantage of any shelter from the wind to reduce possible discomfort.

Early in your setting up a camp, select a dump area in an inconspicuous place nearby and dump all refuse there. A littered camp area is not conducive to sanitation or morale.

### CLOTHING

No matter what you do, you will have to keep warm and dry. If snow got into your boots when you left the plane, shake it out and close the opening it slipped through. If your socks are wet, change them. If you have no spares, several layers of parachute cloth wrapped around your feet are better than wet socks. One pilot who was forced down on the Alaskan Route didn't dry his feet after snow got into his shoes during a walk—and he lost several toes from freezing. Had he




CHUTE CLOTH FOOT WRAP

Use 2-4 thicknesses, 30" square, folded into triangle

*Padding Socks.*

simply taken off his shoes and socks, shaken the snow off them, and then dried his feet and wrapped them with parachute cloth, he might still be flying today. If your boots are big enough, a few handfuls of dry grass stuffed around your feet will make a warm "sock" that is hard to beat—Laplanders have used grass "socks" for centuries. Padding from seat cushions will serve equally well. Don't stuff the material in tightly, though. Leave some room so that there will be adequate circulation.

Keep your hands warm. A lost mitten can mean a lost hand or even a lost life, so tie your mittens together with a long string that runs up behind your neck. A short string connecting the lines across your chest will help keep the strings out of your way. Try to do everything with your mittens on. If you are forced to remove them, stop and warm your hands frequently—more often than seems necessary, because once they get stiff you are in trouble. If your hands get too cold, put them in a pocket or inside your clothing to warm up. But don't wait until your fingers are so numb you can't unbutton your clothing. If you drive yourself too hard at heavy work, you will become exhausted and also perspire a lot. Both perspiration and exhaustion increase the chances of freezing. Therefore, take it easy; don't wear too much clothing while you are exerting yourself. To cut down perspiration, open your clothing at the neck and wrists and loosen it at the waist. If you wear a parka and get hot, let it hang loosely at the waist. If you are still warm, take off an underlayer or two. Don't open your trousers or your boots—it's a sure way to get snow in them. The minute you stop work, put on more clothing to keep from getting chilled. Try wrapping a piece of parachute around you, Indian-fashion; it helps cut off the wind.


OUTER SHOE

Use half of canvas cushion cover

*Improvised Mukluk Boots.*

In summer, protect yourself from insects with a headnet, gloves, and other means. (See Chapter 8.) For additional information about clothing, see Chapter 7.

## SHELTER

In summer, if the weather is mild, you may need protection only from the insects. In winter, however, you can't stay in the open and expect to live, unless you are on the move. You must have shelter even if it is only a hole burrowed in the snow. The type of shelter will depend mainly upon what materials are available, what you need shelter from (wind, rain, snow, cold, or insects), and how long you expect to remain in one location. Regardless of the type, however, the shelter must provide adequate ventilation—first, to prevent asphyxiation, second, to allow moisture to escape.

If suitable natural shelters, such as caves or rock shelves, are available, you need not build. If you must build, however, be sure to pick a good location. In summer, choose a campsite that is dry, relatively free from insects, and near fuel and food. Avoid areas that might become flooded. In summer, the lee of boulders and shelving rocks provides dry campsites. To escape insects, look for a cold lake, a breezy ridge top, or a place that gets an onshore breeze. During insect season, sites in forests and near rapid brooks are undesirable. During winter, choice

of a campsite will depend on protection from wind and nearness to fuel and water. In high mountains and rugged terrain, avoid areas that you suspect are subject to avalanches, floods, rockfalls, and battering by winds. The bases of steep slopes are to be avoided because of falling rocks. As a rule, a camp well up on a valley slope is more comfortable than one on a valley floor.

Consider all these factors. Remember also that you're not building a display home or an apartment house. The smallest and simplest type of shelter that meets your needs and can be made with materials you have on hand is the best shelter for you.

### Arctic Survival Tent

One of the best types of survival shelters, easily put up and giving good protection, is the Arctic Survival Barren Land Tent. This tent, which is now in production, will soon be available in the field as part of the survival equipment carried in the plane. It accommodates three men comfortably and four men satisfactorily. It is high enough to permit one occupant at a time to stand in a stooping position while dressing or undressing. Yet it is not so high that it permits the heat to rise above the space occupied by the personnel. The tent weighs only 25 pounds but is strong enough to withstand winds of 100 mph and gusts of 125 mph.

Fabricated of neon-red, fluorescent nylon material, it is useful also as a visual signal. The fabric of which it is made is water repellent and excludes wind-driven snow and water, but, at the same time, it permits the escape of CO and $CO_2$ to minimize the chances of asphyxiation. There is no waterproof coating or impregnation in the fabric, however, and the tent remains pliable and lightweight. Another feature of the tent is its built-in floor, which increases protection and makes it easier for inexperienced personnel to pitch the tent.

The tent is of "A"-pole construction. Four sectional duralumin poles slide from the bottom through cloth tubes to the leather reinforced apex of the "A". They are tied in at the bottom.

Two men can erect the tent easily. Proceed as follows:

1. Insert and tie in the poles.
2. Stake down the apron securely.
3. Measure out the proper distance for the ridge rope and wall stays, and drive in the stakes. Tie the stays to the stakes to prevent the tent from blowing away during erection in high winds, making sure first that the "A", formed by the poles at the end, points into the wind. (On the,

*Arctic Survival Tent.*

ice pack or when the ground is too hard to drive in stakes, you can use blocks of ice or snow to hold down the ropes.)

4. The man on the downwind ridge rope then takes up the slack as the man on the upwind ridge rope pays out.

5. When the ends are perpendicular, the man who is upwind makes his end of the rope fast and then the man who is downwind takes up the slack and makes his end fast.

6. Make the side stays taut, and the tent is pitched.

There is an egg-shaped tunnel entrance attached to each end of the tent. This type of entrance makes it easier to enter and leave the tent and provides a means of closing the entrance completely to exclude wind-driven snow during blizzards, or to adjust the opening in such a way as to afford proper ventilation. These tunnels are advantageous, also, in that, by tying them from the inside and placing equipment in them, you provide more room in the tent for personnel and, at the same time, modify the flat surface of the end to one that offers less resistance to the wind.

Still another feature of this tent is a disposal hole, 12 inches square, fabricated at the left-hand corner of the floor for use as a latrine and for wastes from camp living. This hole is covered by a flap that extends 2 inches over all sides. It is sewn on one side and tied down on the opposite side by means of loops and tie tapes.

**Airplane Shelter**

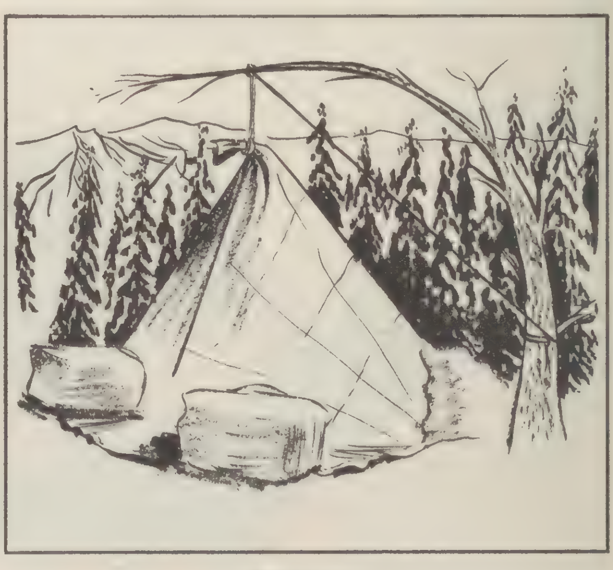
In the summer, you can live in the airplane comfortably if you make it tight against mosquitoes, but be sure to cook outside to avoid the danger of explosion. In the winter, the airplane is a very poor shelter, as the metal carries heat away very rapidly from any source of heat you have, including your body. Any type of shelter involving the use of the airplane, as for example, a shelter made by building up blocks of snow to the wing and throwing a tarpaulin over it, is a very poor, even dangerous, type of shelter. It is poor because the metal of the airplane conducts the heat away from the shelter and the wind frequently raises the wing, releasing the warm air in the shelter. It is dangerous because of the gasoline in the wing. You will be much better off with any kind of improvised shelter not in direct contact with the airplane.

**Parachute Shelter**

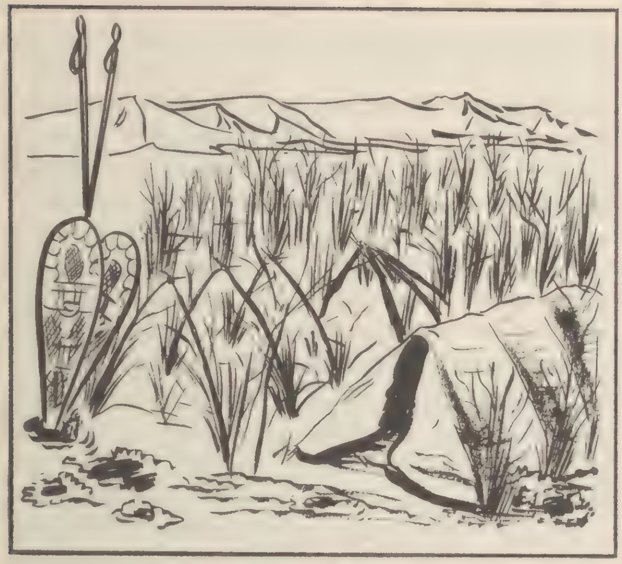
For solid comfort, especially in drizzly weather and during the bug season, the best shelter is a tepee made from your parachute. In it you can cook, eat, sleep, rest, and make signals—all without going outdoors. To build a paratepee, you will need a number of good poles 12 to 14 feet long and the parachute. The details are described in the booklet in your parachute pack, "Emergency Uses of the Parachute".

You can make a simpler parachute shelter by using a single pole as a center pole, or even by holding up the center of your tent with a rope tied to a limb on a tree.

*Parachute Shelter.*



*Paratepee.*



*Willow Shelter.*

*Lean-to.*

You can improvise a simple pup tent by placing a rope or pole between two trees or stakes and dropping your parachute over them. Stretch the corners down and secure them with stones or pegs.

**Willow Shelter**

On the tundra, where willow trees are available, you can make a satisfactory shelter by using a number of them tied together securely as a framework over which to put your tarpaulin as a cover. You can also use snow shoes from your emergency kit, skis, or parts of your plane as supporting parts of this framework. There is no particular detailed design for this type of shelter, except to make it in such a way as to provide only enough room for you, your extra clothing, and your emergency equipment. The open end of this shelter, as in any other type of shelter, should be at right angles to the prevailing wind. Arrange the tarpaulin cover over this shelter in such a way that you have a flap over the entrance to protect the entrance from drifting snow. Pack down all the edges of the tarpaulin around the shelter with snow to keep the wind from blowing snow under it.

**Lean-To Shelter**

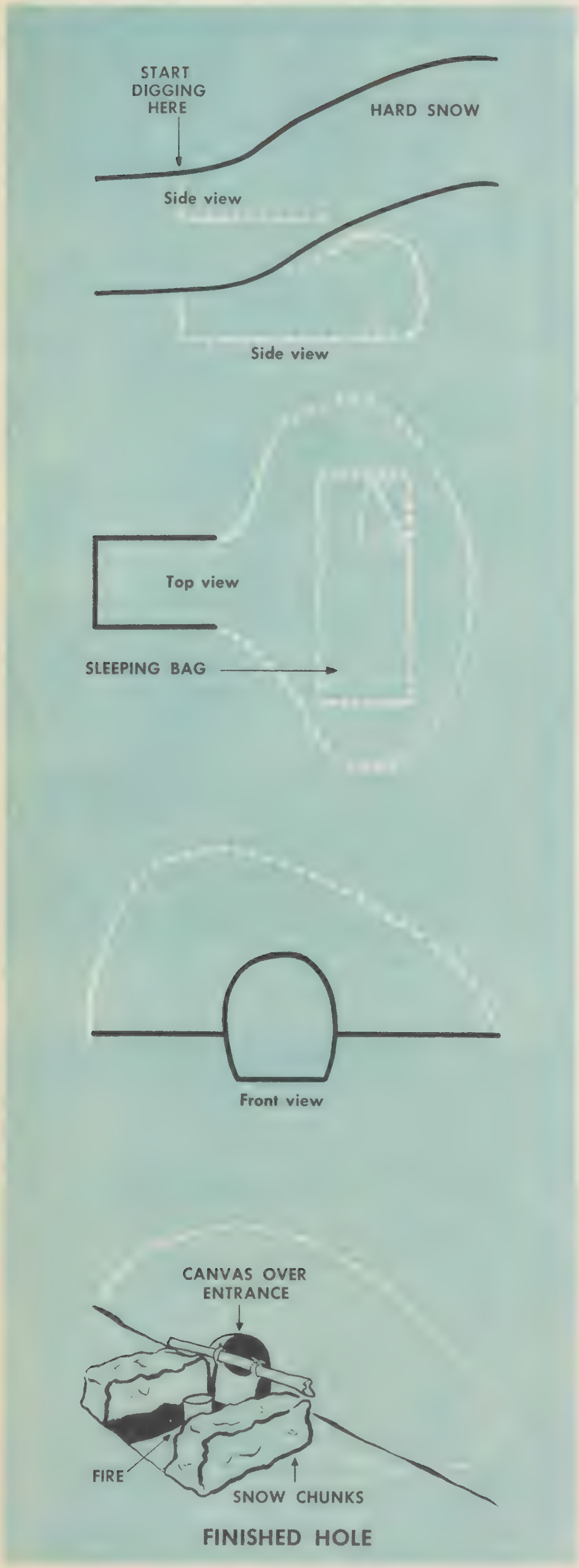
In a wooded area, a lean-to makes a good temporary shelter. Support a pole between two trees at a height of 4 to 6 feet from the ground by resting it on the branches or by binding it to the trees with a rope or even tough bushes or spruce roots. Lean poles against this ridge pole, closely together and slanting gently down to the ground. If the trees are too scattered to provide support for the ridge pole, cut partly through a single tree a few feet above the ground and push it over. The branches will hold it in a more or less horizontal position and will provide the framework for a satisfactory shelter. Cover the poles of the shelter with pine or evergreen boughs, with the pine needles facing downward. If you have a tarpaulin, you can use it to good advantage as a roof for the shelter. Make your fire in front of the shelter and, if possible, set up a wall of green logs behind your fire to reflect heat toward the lean-to.

**Ice and Snow Shelters**

On pack ice or snow covered barren land you have your choice of two methods of building a shelter—you can either dig in or build up. Digging in is easier and is more practicable for a man who is alone.

SNOW HOLE. The first thing to check for before digging in is the quality of the snowdrift. If the snowdrift is pretty compact and has a hard crust on it, you will be able to make a safe snow hole in it. Where the snow throughout the drift is light and fluffy, however, it is likely that the next heavy wind will move the drift—perhaps even blow it away altogether.

The larger the snow hole you attempt to dig, the more work it will be and the more heat you will require to stay warm in it. Don't try to dig a hole large enough for your whole family. All you need is enough space to get yourself, your clothes, sleeping bag, and some small pieces of




*Building a Snow Hole.*

emergency gear inside. Even that will take the best part of a day.

The best type of hole in a drift or edge of a snow bank is one that goes straight into the bank far enough to reach old, hard snow, then extends parallel to the drift, forming a "T" shape. The tunnel into the drift will serve as your entrance way and therefore should be no larger than is necessary for you to crawl into and throw out the snow you remove while digging your sleeping hole.

When you start digging into the drift, you will probably find the snow soft enough to dig out with a shovel. As you get deeper into the drift, however, into the older and more compact snow, it is best to cut out chunks of snow with a saw. If you have no saw, use your shovel as a knife, cutting out chunks of snow by jamming the shovel into the snow and prying out the chunks.

Make your sleeping hole long enough to permit you to stretch out and high enough to give you head room while sitting down or crawling in and out. Scoop out a shelf on one side of the hole for your candles. In such a small hole, a single candle will soon make it warm enough for you to shed your parka and outer trousers. The candle will produce enough heat also to melt some of the surface snow in the hole. Make the ceiling of the hole dome-shaped, therefore, so that the melted snow will run down the sides instead of dripping. The arch shape will also give greater structural strength to your shelter.

Cooking in the hole is dangerous because your stove may tip over and ignite your clothes or some survival equipment. Besides, there is the danger of carbon monoxide. A good place to set up your stove is right outside the entrance way. To break the wind, pile up the chunks of snow you sawed out in order to make your hole. Work them up in the form of a wall about four feet high. This will not only protect your stove from the wind, but will also serve as a good windbreak for your entrance. To make the entrance even more windproof, you can fashion a cover from your seat cushions, parachute, or other materials.

During the process of digging out the snow hole you will undoubtedly get warm enough to sweat. Shed your outer garments to prevent sweating, but be sure to roll them up tightly and put them into the plane or some other sheltered spot to prevent snow from accumulating on them. Remember, too, that you will get

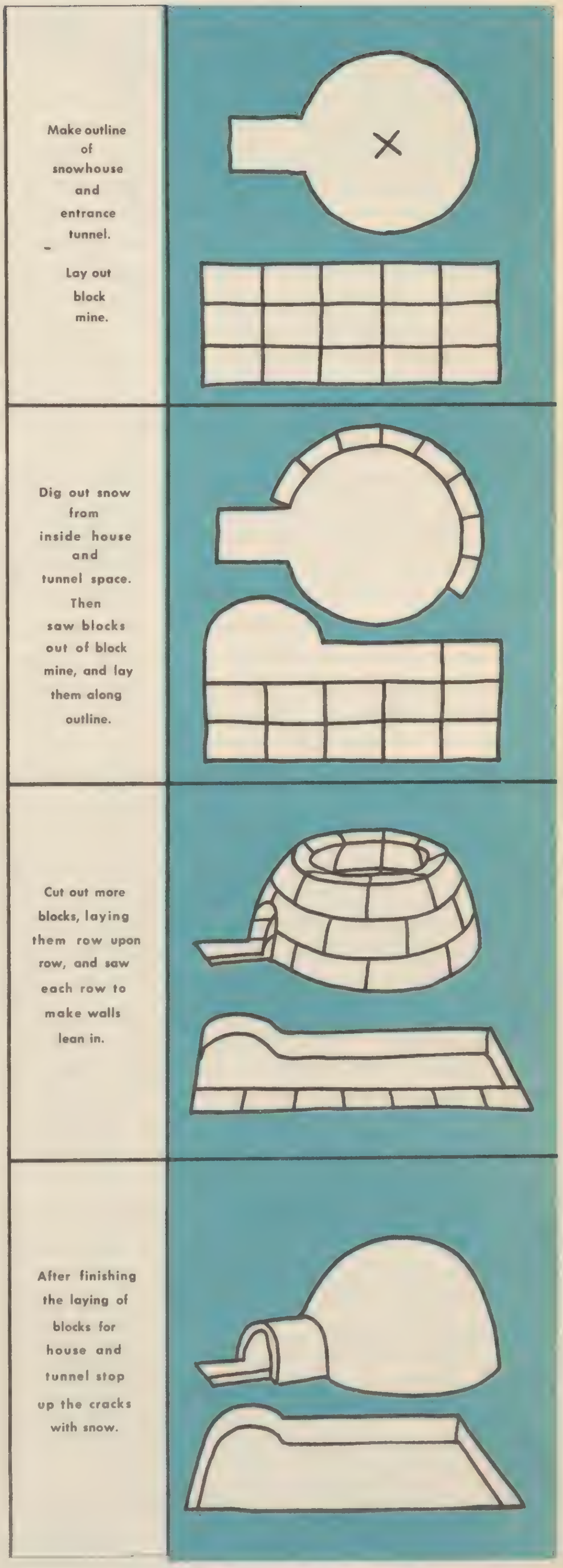
wet from the snow in digging this shelter; so set aside some dry spare clothing into which to change when you're through. An anti-exposure suit, if you have one, is an excellent outer garment to wear while digging a snow hole.

Snow holes built in the manner just described are excellent shelters, but training situations have shown that a number of men dislike snow holes because of claustrophobia and unfounded fears that the snow hole might cave in, that they might become asphyxiated in it, or that the entrance might become so covered over with drifted snow that they might not be able to get out. These fears have no basis in fact. Snowdrifts of hard-packed snow with crusts on them are strong and sturdy. Snow is an excellent insulator because of the large amount of dead air in it and, for the same reason, provides sufficient air to enable you to breathe even when the hole is completely covered over. As for drifted snow piled up over your entrance way, if you take your shovel into the snow hole with you, you won't have to do more than a little prebreakfast PT in order to get out.

SNOW HOUSE. Another kind of shelter that utilizes all the insulating and structural qualities of snow is a house built of snow blocks. This type of shelter can house more than one person, and therefore two or three crew members can team up and build one.

Pick a spot where there is at least a foot of snow between you and the ground or ice. Figure out how much space you'll need—a house 6 feet in diameter is sufficient for one man, 8 to 10 feet for two or three men—and draw a circle that size in the snow. Probably the best way to draw the circle is to set up a center point (a stick or shovel) and describe a circle about it. After drawing the circle to the proper diameter, use a shovel and dig the snow out of the space in the circle. Since space inside snow is the requirement, it doesn't matter whether you build up or dig down—and digging is easier than building. So, if you have enough snow under you, dig down a couple of feet. While you're at it, dig yourself an entrance ditch along a line perpendicular to the prevailing wind.

After finishing the digging, start manufacturing blocks for the walls and roof of your house. Again lay out your work first by drawing lines on the snow surface. Keep your block mine close to the snow house to save lugging blocks any farther than necessary. Draw parallel lines on the snow about 15 inches apart and 15 feet




*Building a Snow House.*

long. Then draw more lines perpendicular to these, separating the surface of the snow into rectangles about 15 inches by 20 inches. You're now ready to start the block making. Saw down along the two outside 15-foot lines, cutting at least 15 inches deep. Then dig the snow away for several feet along the outer sawed line, cut under the line, and saw across the line to get your first block out. This one is the hardest. After you have removed this block, you can stand down in the hole and wield the saw with fine results, making all the 15″ x 15″ x 20″ blocks you need. Carry the blocks over to the dug out area and set them around the outside of the circle on top of the surface snow to form the first ring of blocks.

It's time now to decide how high the dome is going to be. This depends, of course, on how far you've dug into the snow, how tall you are, and whether you want a palace in which you can stand or a hut in which you can sit. In making this decision, remember that the larger the house, the more energy you'll have to use to build it and the more fuel to heat it. Both are precious items in the polar regions. Don't figure on too gigantic a project.

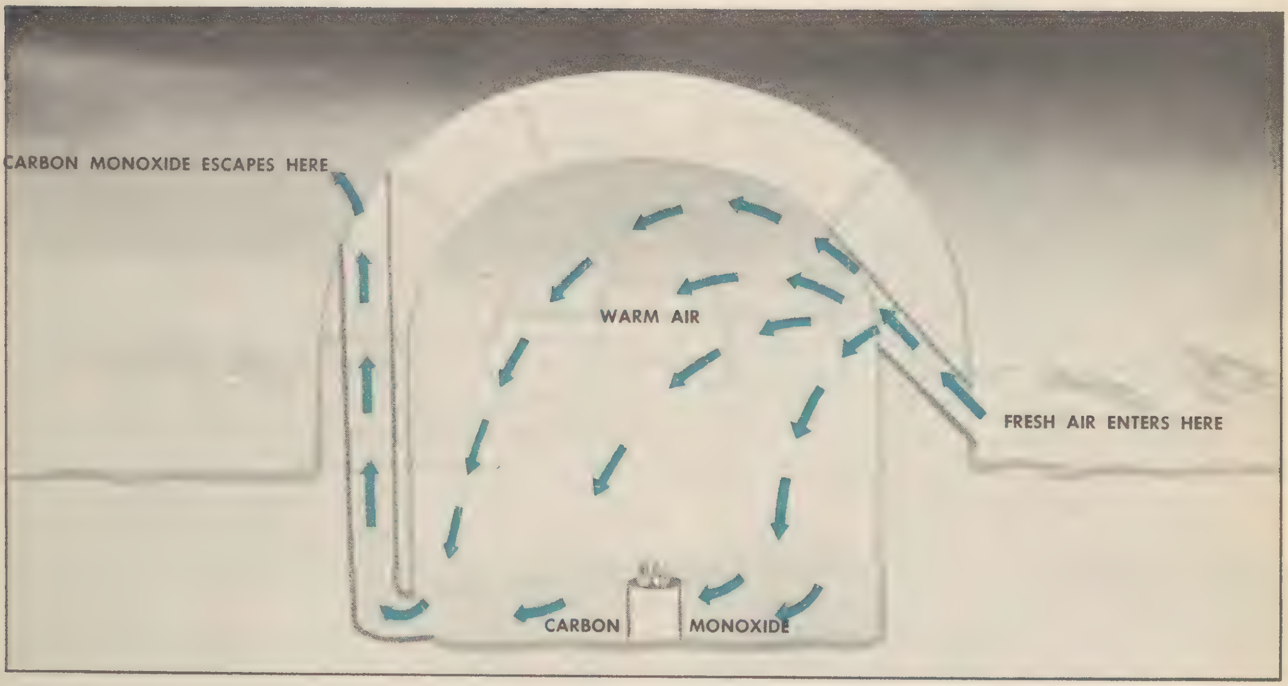
Once you figure how many snow blocks high the house is going to be, you're ready to cut off the top of the first layer of blocks at an angle which will cause the next ring of blocks to lean in toward the center of the snow house. This repeated process—laying a ring of snow blocks, cutting off their tops at an angle, then laying another ring on top—will give you the dome shaped roof. A saw is the best thing for cutting off the angular wedge of snow from the tops of each ring of blocks. Stand inside the house and use a little mental geometry to determine the angle at which to cut each ring of blocks. This angle of cut increases as you approach the top of your house.

Keep on cutting, hauling, and setting up rings of blocks, trimming off the excess and cutting the tops at the proper angle, until you reach the top. The last block is the toughest, and there's no secret process or magic word to aid in getting it into place at the very top. Just look at the hole into which the block must fit, and cut out a block as close to that shape as possible. Lean over the snow house and drop it on. Then get inside and use the saw to trim it to fit.

Even an experienced builder finds that there are cracks between blocks and an irregular and rough shape on the inside when he's through. Now's the time to correct that. Fill the cracks with as moist a snow as you can find. Use it as a putty and you'll have a cozy, draft-free house. Then shave the inside of the house into a regular smooth surface and when you light a candle or gas stove, the melting snow will run down the sides instead of dripping on your clothes and sleeping bag.

There are still two things to do to put on the finishing touches—first, cover the entrance ditch with blocks to make a tunnel; then, provide a means to ventilate the house. The method of ventilating a snow house depends on whether you're going to have fire and do your cooking inside the snow house, or whether you wall up the end of the entrance and cook outside. If you cook outside, a small hole through the side of the snow house opposite the entrance tunnel will provide sufficient ventilation. However, if the snow house is large enough to cook in without danger of setting your clothes or sleeping bag on fire, you must have a ventilating system which will enable you to remove the carbon monoxide gas generated by the stove. There is a vent system you can use. It is based on two facts—one, that the air inside the snow house is much warmer than the outer air, and the other, that carbon monoxide is a heavy gas and will fall to the floor of the snow house as it is generated. Two holes are therefore needed to get the $CO_2$ out of the snow house—one entering the house at the lowest part of the floor and running vertically up through the wall of the snow house like the chimney of a fireplace, and the second starting as low as possible at the outside of the snow house, running at a very steep angle from the outside upward to the inside, and hitting the inside of the house a couple of feet above the floor. Using this system, you can cover up the entrance tunnel to your snow house and burn a gasoline stove with no danger of carbon monoxide poisoning.

The diameter of the holes will depend on the instrument you use to make them. Any type of pole or piece of metal that can be pushed through the snow can be used. If you are on a heavy bomber that carries a long handled shovel, just force the shovel handle through the snow to make the vent holes. On another type of plane, improvise something from your airplane or emergency equipment. Life raft oars and mast sections, for example, will do fine. Clear out vent holes from time to time to prevent drifting snow from blocking them.




*Snow House Ventilation.*

**Using the Shelter**

After your shelter is constructed, use it—not only for yourself but for your belongings as well. Snow is the greatest thief in the Arctic. If you leave any of your equipment out in the snow, it may well be buried or blown away. Keep your emergency equipment and extra clothes neatly arranged in your shelter. This will not only make it easier for you to find what you want quickly but will keep you from bumping into things and knocking them over when you crawl into your shelter.

Brush snow off your clothes and footgear before you enter your shelter. Inside, the snow will melt and you will find it quite difficult to dry your things. Whenever you leave your shelter, cover over the entrance for the same reason. Set up a pole of some sort to mark it in case snow drifts over it. Unless it's impossible to secure insulation, never place your sleeping bag on the bare ground or the ice. Always place something under your bedding; if nothing else, snow will provide a good insulation. Normally, however, you will be able to improvise some other insulation readily. You can use parachute seat cushions or even an inverted and inflated rubber life raft as a mattress. Other insulation materials from the airplane are seat cushions, snowshoes from the emergency kit, or cardboard from the ration boxes. In a snow hole or snow house, place a tarpaulin under your sleeping bag to prevent its getting wet from the melted snow running down along the wall.

In wooded country or in grasslands you can find natural insulating materials. On the polar tundra, dry reindeer lichen, shrubs, or dry grass are effective insulating and mattress materials. In timbered areas, evergreen boughs can be used. Twigs and small branches of trees are especially suitable for mattresses because they are springy and soft. Twigs and needles of evergreen boughs are preferable to twigs from broad-leaved trees. Your mattress can be as thick as your time and materials permit.

Usually a close, well-laid, bough bed a foot thick is adequate for all conditions. However, if the twigs are very bushy and springy, a much thinner bed will do. Areas in contact with pressure points of your body should be well padded. Bough beds that have been slept on for many nights gradually lose their resilience and need to be re-laid or replenished with fresh boughs. Tuck the stubs of fresh twigs into the old bed, laying them shingle-fashion. Peg or fit logs three or more inches in diameter at the side of the bough bed. This helps to keep the boughs in place and checks a restless sleeper who otherwise might roll into the fire. It also keeps the bed in shape by preventing men from walking or tripping on the boughs.

## FIRE

In survival, there's no question at all as to the value of a large cheerful fire. Aside from its warmth, it's a great asset from a moral standpoint and an aid to rescuers as well. However, many people have sacrificed so much just to have a large fire that they have defeated some of its purposes. So, instead of starting a raging inferno as soon as you hit the ground, stop for a minute and figure out what you want it for. Then design a fire to meet your needs. A B-29 crew picked up last winter, for example, had a strong fire going when found, but had completely neglected to build any sort of shelter, or even to erect a windbreak. Naturally, these men were cold and uncomfortable. If they had put as much effort into building a shelter as they had in building a blazing fire in the wind, they would have discovered that a single candle in the shelter would have netted them much more comfort than ten logs burning in the wind. The wrong kind of a fire—one that doesn't meet your needs—can be more detrimental than helpful.

### Starting the Fire

Making a proper fire starts a while before you light a match. It starts by protecting you and the fire-to-be from wind. In wooded areas the standing timber or brush usually makes a good enough natural shelter, but in open timber or low brush country erect some kind of barrier, if the wind is blowing, to break that wind, using materials and methods of construction similar to those you used in building your sleeping shelter.

A row of snow blocks, the shelter of a pressure ridge, or a scooped-out side of a snow drift will work well on the ice pack. A circular wall of brush, cut and stuck in the snow or ground, will work well in willow country. A ring of evergreen boughs is fine in timber. Make this wall about four feet high and, except for an entrance way, circle your fire area with the wall in windy weather. The extra warmth you will get from even a small fire with a wind breaker will more than repay you for your efforts in constructing the wall.

The next step in fire-making is gathering necessary materials to start and sustain a fire. These materials can be divided into two classes—fire starting and fire sustaining. The airplane will help you out with the first type, if not both. There is gasoline, oil, rubber, cloth, dry wood, paper, celluloid, and many other man-made products, which make better kindling than whittled chips of trees.

*A Windbreak is Essential.*

Good kindling includes anything that burns easily, especially lightweight materials that ignite directly from a match and furnish heat enough to light the larger pieces of wood, coal, or fat that constitute the principal fuel. Tufts of dry grass, birch bark, sedges, pine needles, the pulpy interiors of many plants in the marshland, and the dry lichen that covers the twigs of black spruce and tamarack meet these requirements.

If you have animal fat (blubber) available, you can improve the kindling qualities of any of these types of kindling considerably by laying the fat between the kindling and squeezing. This forces the oil out of the fat and causes it to be absorbed by the kindling.

Your fire is something that must grow from the match to burning logs; so use your kindling at the base of logs or other heavy fuel. Place some kindling on the ground and lay a few smaller sticks over it. Then distribute more kindling toward the center of those small sticks and continue building up the pile of kindling and sticks until it's about a foot high. On the center of this pile, lay the ends of four or five logs, letting the logs themselves stretch out from the center.

If you must build a fire on the snow, lay a base for it, of logs, cowling, or other materials, to prevent the fire from melting a hole in the snow, falling into it, and going out. On high land, when the forest litter is dry, make a clearing for your fire; otherwise, you may start a fire that will be hard to put out. In any case, always put your fire out completely before leaving a camp site.

In lighting a fire, strike the match and hold it so that any breeze will blow the flame into the fuel—not out of it. Handle any other flame-producing device similarly. If you're short of matches and have any paper or oil-soaked cloth, use one match to light the paper or cloth and use the paper or cloth to light the kindling of the fire. When you strike this first match, you'll really be thankful you've taken the time to build the windbreak around the fire area; and as you see the flames leap up through the tinder and small sticks to the larger sticks and finally consume the ends of the logs, you'll appreciate the reflected heat and lack of wind as you cook and dry clothes around this fire.

Starting a fire without a match is difficult under the most ideal circumstances and is really tough under low temperature, high wind conditions. So start worrying about this problem before take-off and provide yourself with an ample supply of matches in waterproof containers on your person. Don't depend on the next fellow; bring your own.

*Cross-Section of Fire.*

However, if you're stuck with a pocketful of wet matches (or have no matches at all) the flint and steel in your emergency kit will prove extremely valuable. This flint and steel will produce a spark, but only a small one, which you must build into a fire. In warmer weather, you can get sparks from a battery instead of the flint, but, at low temperatures, the battery will not produce a spark sufficient for fire-starting.

A spark will do you no good at all if you strike it in the wind in an attempt to light a soggy piece of wood. Plan your fire-starting carefully, therefore, and use your most volatile kindling material. Gasoline serves this purpose very well. Oil that is not congealed can also prove helpful.

Where game is scarce and ammunition is plentiful, it may be wise to remove the gunpowder from a cartridge or shotgun shell and put this at the base of your fire, using the flint spark to ignite it. If you are without flint, or if it is too cold to obtain sufficient sparks from a battery, your next best bet as a fire starter is a magnifying glass or any bent glass or plexiglas which may be utilized as a magnifying glass. However, even where it is visible, the Arctic sun is weak through the winter months. It will take much patience to hold the magnifying glass in a position that will focus a spot on gunpowder long enough to get results. And if you don't protect your kindling against the slightest draft when using the sun's rays as a fire starter, even patience won't help you.


*Starting Fire with Cartridge.*

You can also use gunpowder and cartridges to start a fire without the aid of the sun or a spark. Build a properly sheltered pile of kindling and wood and put the powder from a shell or shot at the base of the stack. Then hold a powderless and bulletless shell or cartridge in a pair of pliers close to the powder at your base of your fire and strike the outside of the shell primer with a sharp metal object. Another alternate, if you have a side arm, is to dump the gunpowder of several shells at the base of the fire in the usual manner, replace the shot or bullet from a shell with a piece of paper or cloth to hold the powder in position, and load this cartridge into the chamber. Then aim the gun at the powder at the base of the fire, holding the end of the muzzle at least an inch away from the powder, and pull the trigger.

If you have a tin can gasoline stove (described later), try removing the bullet or shot from a cartridge or shell, even if you have a long-barrelled gun, hold the gun barrel inside the tin can stove (but not under the sand or gasoline), and fire the piece into the stove.

A pyrotechnic pistol fired into the base of a well built pile of kindling, sticks, and gasoline or oil, is another way to get a fire started.

**Fuel**

Fuel is available in many parts of the Far North. In some places there are outcroppings of coal at the surface of the ground and sometimes lumps of coal are washed up on the beaches. This coal is commonly of the soft variety which produces a black smoke and an odor like asphalt.

In the tundra you will find some clumps of low growing willows and birches which can be split up into fine pieces and burned green. Birch is quite oily and if split fine will burn even when wet. In addition to standing timber there are some limited sources of dead wood. Sometimes you can find driftwood in the slack waters of river mouths and along the seashore where it has been cast up by storms. Driftwood is a great traveler and can be found on almost every shore of Alaska.

Most sub-polar lands are timbered. Hence, fuel in these regions is usually wood. The driest wood is in dead standing trees. Frozen green timber appears dry but is relatively heavy and has a hard ringing sound when struck with an ax. Frozen dead wood, on the other hand, has a dead dry rattling sound when struck. In living trees the branches above snow level are the driest. Places from which the bark has fallen are drier than those covered with bark or lichens.

Make every effort to keep a fire going at all times, even if it's a small one that must be built up as needed. If you are down in an area where there's plenty of wood and you have a crew with you it's a good idea to spend the efforts of one person in gathering wood to keep a central fire burning. Under these conditions it's more successful to take turns sleeping than to pile your fire up with logs and all sleep at once. However, if you are alone, put a couple of logs on the fire and sleep for short periods of time, but keep a little fire going if at all possible. It will serve as a good signal and will also save your precious supply of matches.

Remember, though, no matter how plentiful wood is it still costs you energy to drag it to the fire area. Don't throw more logs on the fire than you need at any one time. Lay them around the inside of your windbreak and sit on a few of them. Try to gather them through the light of the day and bring them as close to your fire area as possible so that you won't have to stumble through the darkness looking for wood when night comes.

**Gasoline Stoves**

While you'll find an abundance of driftwood along most of the Alaskan coastline and throughout the northern Canadian shores, and while most of the inland areas of the polar region provide standing and fallen timber for fuel, there are still the great frozen sea areas which are barren so far as wood is concerned. The lack of wood does not mean that you cannot have a fire if you stay with your plane, for the same type of material which makes kindling can also sustain fires.

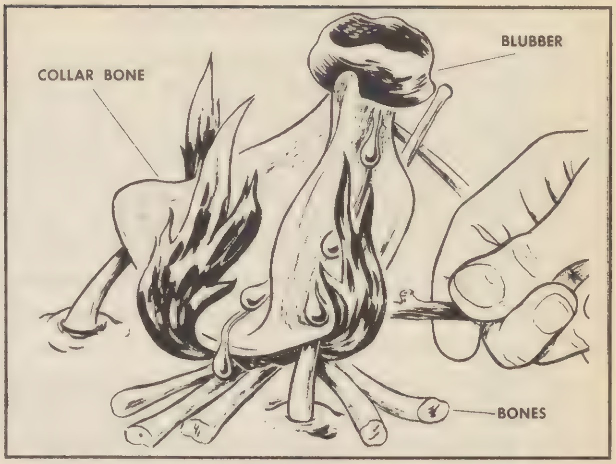
The simplest and best fuel from an airplane is gasoline. But if you plan on burning gasoline, remember that you must use some other material as a wick—you can't just light a pot full of gasoline. You can make wicks of any material that will absorb gasoline. Parachute webbing, for example, makes a good wick. Roll it into a ball and place it in the bottom of any type of receptacle or open-top can with part of this wick sticking out above the gasoline. Another good way of burning gasoline is in a tin can stove. Just punch holes in the side of the tin can, cut the top of the can at intervals, and bend the sections down, as shown in the illustration.

Fill the bottom of the can with two or three inches of sand, then pour gasoline into the bottom of the can so that the level of gasoline does not rise above that of the sand. To use this gasoline stove, simply light it and leave it burning until all the gasoline is gone, then refill it. This kind of stove beats the wick type in that the sand never burns out, while a wick will be consumed.

Reading about a tin can stove, which is a really fine little device for cooking and heating, is not going to help you a bit if you are down on the ice pack with just gasoline and tin cans. There are certainly no sandy beaches there. However, if you plan your emergency equipment properly, you'll find room somewhere in your airplane for a few empty tin cans and a couple of pounds of sand, because this simple little stove will work for a long period of time. It does not tip over rapidly, and can therefore be used in small interiors. It has no mechanical parts to get out of order, and requires no cleaning. In addition, it will burn any type of aircraft fuel.

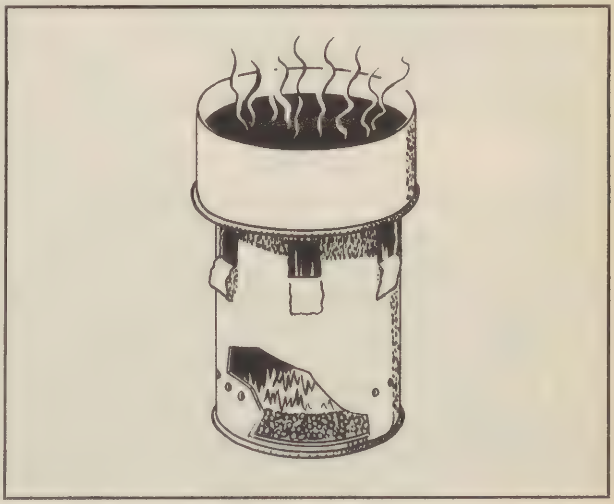
#### Fires of Animal Fats

If you are in any danger of running short of food don't use as fuel anything that can be eaten. You get more heat value from food that you eat (raw, if necessary) than from food that you burn. Similarly, clothing that you wear on your back is the source of greater continued warmth than the same clothing used as fuel. However, if you have plenty to eat you may use animal fat as fuel. Eskimos burn seal blubber with seal bones as the wick. They make a little pyramidal pile of them. They then saturate a small rag with oil from a small piece of blubber, light the rag, place it inside the bone pile, and lay the blubber carefully on top of the pile. The heat rends the oil from the piece of blubber and the oil drips onto the now-heated bones and ignites.




*Blubber Fire.*

You can make a better blubber stove from a tin can about the size of a one-pound coffee can with the cover removed. Punch it full of holes—small holes not over one-fourth inch in diameter are best. Punch the sides and the bottom. Then build the wick from seal bones, a piece of canvas, dry tundra moss, or a piece of sealskin with the hair-side up. Impregnate the wick with the oil, light it, and place the perforated coffee can over the flame. Lay the blubber on top of the can. The oil dripping from the blubber into the heated air inside the can will burn far hotter than it does when the blubber is placed directly on the wick without the can. The smell is somewhat akin to that which rises from the Chicago stockyards on a hot July day, but you can be sure that if you are ever reduced by necessity to burning blubber the cheery flame will certainly neutralize the odor.



*Tin-Can Stove.*

## GUNS AND AMMUNITION

Take very good care of your guns and ammunition. They may be your only means of securing food. Even though you haven't fired a shot, clean the inside of the barrel of your rifle daily by drawing a piece of dry cloth through it several times. To do this, attach the weight in your fishing kit to a short section of the line and attach a piece of cloth to the other end of the line. Then drop the weight through the barrel and pull the cloth through.

In rough country, handle your gun carefully to protect the front sight from being jarred out of alignment through striking on rocks or against brush.

A shotgun works fairly well even with dirty barrels and no sights at all—but at least keep the breech mechanism clean and dry. In very cold weather, don't oil the gun. Lubricate with graphite, if available. If oil gums up the firing pin, even the best gun may fail to function at 30° below. To keep the gun from "sweating", don't bring it into the warmth.

If you have an over-and-under gun, be particularly careful with the "thumb selector" by means of which you can select either the rifle (selector in *up* position) or the shotgun (selector in *down* position). This mechanism comes loose easily, and if it falls out or gets stuck, only one barrel of the gun will fire. If you're out of ammunition for that particular barrel, the gun will be useless.

Keep your ammunition clean and dry. Before using cartridges from a freshly opened box, rub the grease off them with cloth, leaves, or tree bark and save the material you rub with for fire-making. In rainy weather, carry paper shells in an inside pocket. If you have to swim a stream with your clothes on, throw your ammunition across, then cross over yourself.

## FOOD

You can satisfy both your hunger and the basic requirements of a healthful diet over a prolonged period—but it takes planning, ingenuity and effort. Emergency rations from plane and kits, plus possible snacks from your pockets, and flight bag, are immediate sources of survival food. It is possible, of course, that a rescue plane will find you in a few days and drop additional rations. However, you can't count on "manna from heaven", and you'll be wiser to assume that your supplies must last several weeks. S-T-R-E-T-C-H them. Be scientific about it. Make a list of the food on hand, and plan your meals so that available rations will cover a two-week minimum. Then set a daily quota for each man. Every few days take inventory and adjust allowances according to the remaining stock. Be sure to place your food in caches to protect it from rain, ground moisture and animals. Whenever it is possible to watch it, however, leave some of it out and shoot the animals that come to steal it. A small food investment of this sort may net you a much larger food supply in return.

No matter how large your supply of emergency rations, however, you will need to supplement your rations with food secured by hunting and fishing. Leave a man in camp at all times ready to signal when a plane comes over, while the rest of the group splits up and searches for food. One man can be detailed as fisherman; others as hunters—to be in the field as much of the time as practicable. At first travel only short distances from your camp. Then, as you learn to know your neighborhood, increase the distance and search out the potentialities around you. There might be a trapper's trail half a mile away. Incidentally, when you go on a hunting trip, be careful to blaze a trail back to camp. In open country, set up piles of rocks or wands. A change of weather may bring on a sudden blizzard. If you lose your way in a storm, hole up in the snow and wait out the storm. Otherwise, you may get permanently lost.

## HUNTING

Since your food supply depends to a great extent on your prowess as a hunter, it is well to develop your ability to hunt and your knowledge of animal habits before you are forced to depend upon that knowledge and ability to provide you with food. Therefore, whenever you get the opportunity, study first-hand the characteristics and traits of Arctic animals. You will find hunting, fishing, camping, skiing, and snowshoeing about your base one of the best ways of getting back to nature and finding out what it is doing in the polar regions these days.

You will discover that, with a few exceptions, three types of hunting are available to you, whether you are ten miles from your base or down on the coastline north of the Arctic Circle. These three types are: big game, small game, and flying game. Learn the traits and feeding habits,

the tracks, and the den or nest-making characteristics of the animals in your locale, and you'll have this information ready to use if you need it.

**Big Game**

Most carniverous big animals are much better hunters than the average man. In fact, hunting, killing, and eating other animals is their main occupation. Nature has provided them with senses and equipment to do a good job of hunting, and since they devote their lives to it, you will find this type of animal shrewd and difficult to take with the firearms normally provided in survival kits. In fact, it's not at all strange for a man, while hunting, to come across bear tracks which, if followed, will circle about and join his own tracks. The reason for this is simple. The bear is also hunting, and the man with the rifle becomes the hunted as well as the hunter. However, there's one thing in his favor—that is, that the bear will track and study the actions of this strange prey for quite a while before becoming aggressive. Like all hunting animals, he follows the rule of knowing his prey and attacking at the most opportune time.

Take a tip from these animals, especially when hunting big game. Try to place yourself in the best position in relation to the game before shooting. Approach animals quietly and upwind if you expect to get close enough to use your .22-caliber rifle. Stay behind all the cover you can find and approach as close as possible to your dinner-to-be before leveling off at a vital zone and squeezing the trigger. Take your time. That animal may have been feeding right where he is for the last hour or so. In fact, he may never have been more than ten miles away from the spot on which he is standing. Just don't scare him, and you will usually have ample time to approach, take a steady aim, and squeeze off a single shot which will do the trick.

This method of big game hunting requires patience and lots of it. The first and foremost urge on the part of a man who is hunting for food is to shoot at the first big animal he sees, whether it's running, walking, out of range, or almost completely concealed by heavy brush. The odds are great against killing with a .22 rifle under these conditions, and not only will these shots waste precious ammunition, but will also alert all the animals in the vicinity.

You can kill big game with the .22-caliber survival rifle, but you must get well within range and place your shot in a vital spot. Pumping four or five wild shots into the body of an animal is not the way to do it. One shot which severs the spinal column, cuts an artery of the heart, or penetrates the brain is the best way. With a powerful, high-velocity, big-game rifle it's possible to hit big game in a great variety of places which will prove crippling enough to allow you to approach close and get in a second killing shot. But the .22 rifle will not break hip joints or shoulder blades, nor will it usually fracture skulls or disembowel the animal. Your first shot must kill; if it doesn't, it will probably be the last shot you'll get at that animal.


*Vital Zones.*

In big game hunting it is wise to consider defensive as well as offensive tactics. In the event a wounded animal charges or a bear decides you'd make a good dinner and your only weapon is the .22-caliber rifle-.410-gauge shotgun combination, try to get in a good shot with the .22-caliber barrel first. If this fails, wait until the last possible moment before firing the .410 barrel. This shotgun blast, if fired in the face of an animal at point blank range, will stop or blind almost any animal. You can have confidence in its doing this at eight to ten feet. But if you fire it while the animal is twenty to thirty feet away, the shotgun pellets will merely penetrate his skin and possibly infuriate him more. Above all, in this type of action you must discipline yourself to wait until you know what your shot will accomplish instead of firing your shot to find out.

#### Small Game

Since the .22 rifle can be used to cripple as well as kill small game, the target area when shooting small game covers a large percentage of the body. A bullet which breaks the shoulder blades of a fox is almost as effective as one which kills the animal instantly. Likewise, a rabbit hit in the hind quarter with the charge of a .410 shotgun is not going to go very far. For these reasons you can take more liberties in shooting small game than in big game hunting. You don't have to approach your small game as close, nor are you limited to a few vital spots. Using the .410 shotgun barrel of your survival piece, you can get a good percentage of running small game.

Since most small animals build themselves shelters or use natural shelters and tend to stay in a locality for a considerable length of time, you can survey the entire area around you when snow is on the ground and determine from the tracks in the snow where most of the small game is to be found. Using these tracks, you can find the animals' dens or discover their paths to water holes, and you can sit in a sheltered spot and get good shots at the animals as they enter or leave their dens or as they run along the beaten path to the water hole. You can also capitalize on the old adage that curiosity killed the cat, and, sitting quietly around your fire area in the darkness, watch for the eyes of small animals to appear about the fire. Another trick you can use is to place a decoy or bait in view of your shelter and sit in your shelter and wait for the animals to approach the bait. You can use the entrails of the last animal you got as bait, or the skin of the last animal, stuffed with snow, as a decoy.

#### Flying Game

While here in the States it is not considered sportsmanlike to shoot quail or pheasant on the ground, make a practice, under survival conditions, of approaching birds on the ground or of attracting birds to the ground in your vicinity instead of trying to shoot them in the air. If you spot birds on the ground but out of range, carefully keep some cover between yourself and the birds until you are within range. And if you have good cover and kill a bird with your first shot, stay under cover for a while to see whether the other birds will come back and land in the same area. Frequently they will take off and circle, then come in and land right where they were when you first saw them. However, if you run out in the open to retrieve the first bird you shot, it's very likely that the rest will not return to that area.

As in small animal hunting, it's often easier to attract the birds to the hunter than to tramp over four or five miles of snow looking for birds. If you can determine what kind of food the birds are eating from watching the birds in your area or from the gullet of a bird you have killed, try to get some of this food, scatter it out on the ground or snow in front of you to attract birds to your locality, and establish yourself in a sheltered position to await their coming.

### LIVING OFF THE COUNTRY

#### Food Animals, Birds, and Fish

In most parts of the polar regions, animals are to be found all year around, on land, in lakes, and in the sea. Remember that virtually all animals are edible. However, if you are forced by necessity to live for several weeks on an all meat diet, be sure to eat plenty of liver.

**WARNING**

*Do not eat the livers of polar bears or bearded seals. The livers of these animals contain a tremendous concentration of Vitamin A and will make you sick.*

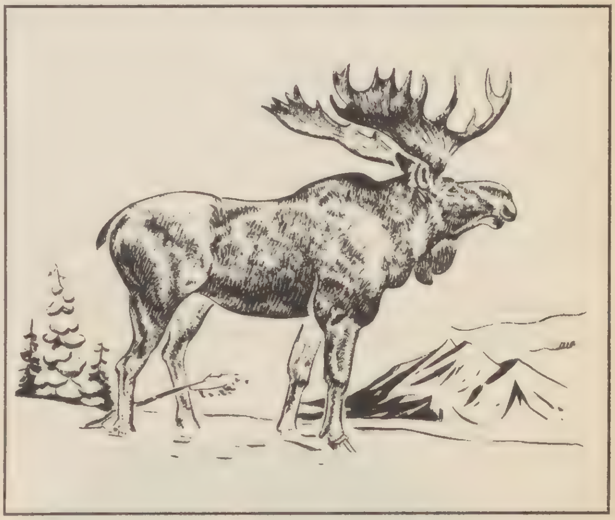
CARIBOU. Caribou usually travel in herds. They are found on the tundra in both winter and summer. Sometimes in summer, they are also found on off-shore islands. Whether caribou are plentiful or not, shoot only as many as you require. Consider the Eskimos, whose need for

food and clothing is as great as yours and whose friendship is essential. In shooting, aim for the shoulder or neck rather than the head; antler prongs make the head a deceptive target. Soft-nosed bullets are more effective than steel-jacketed ones.

Skin caribou promptly, especially in summer. If you do not have time for skinning, at least remove the entrails. When skinning, keep the fat with the carcass rather than the skin. (These suggestions apply to other large animals as well.) The caribou's stomach contents (mixed with oil or blubber) can be eaten. So can the eyes, brain, bone marrow, tongue, entrails, and especially the liver. Caribou meat freezes quickly in winter. Kept frozen and snow-covered, it will last indefinitely.

*Caribou.*

MOOSE. Moose are excellent food animals. Look for them in or near lakes or swamps. In clear, cold weather you can best spot a moose or caribou by climbing a hill or tree and looking for the animal's "smoke" which rises like the smoke of a camp fire.



*Moose.*

MUSK OXEN. Musk oxen are most abundant today on little-known islands north of the continent proper. They live in the wildest, most remote barrens and seek meadowlands between hills and ridges. Keep on the lookout for tufts of their long, dark-grey hair and their soft wool on boulders in muddy spots. They live on grasses, heather, and small bushes, and, when necessary, will eat moss and lichens.

Musk oxen are easier to stalk and shoot than caribou. If possible, approach and shoot them from behind cover. If they are startled, they may clatter up the nearest hill and bunch tightly together, facing you with lowered horns. In that case your approach is easy. But face and forehead shots are almost sure to be wasted; a neck or shoulder shot is the surest. In winter, skin animals quickly before the meat freezes solid. Prepare the meat as you would caribou.

*Musk ox.*

SEALS. Seals are widely distributed and generally common. Their flesh and liver are excellent food. (*Do not eat the livers of bearded seals* however, as they contain a dangerous concentration of Vitamin A.) In summer and autumn, seals come to the surface of the water in order to breathe, and as their heads pop up, they make good targets. Seals sink in fresh water all year around and in salt water from May through October. They generally float in salt water from November through

Hair Seal.

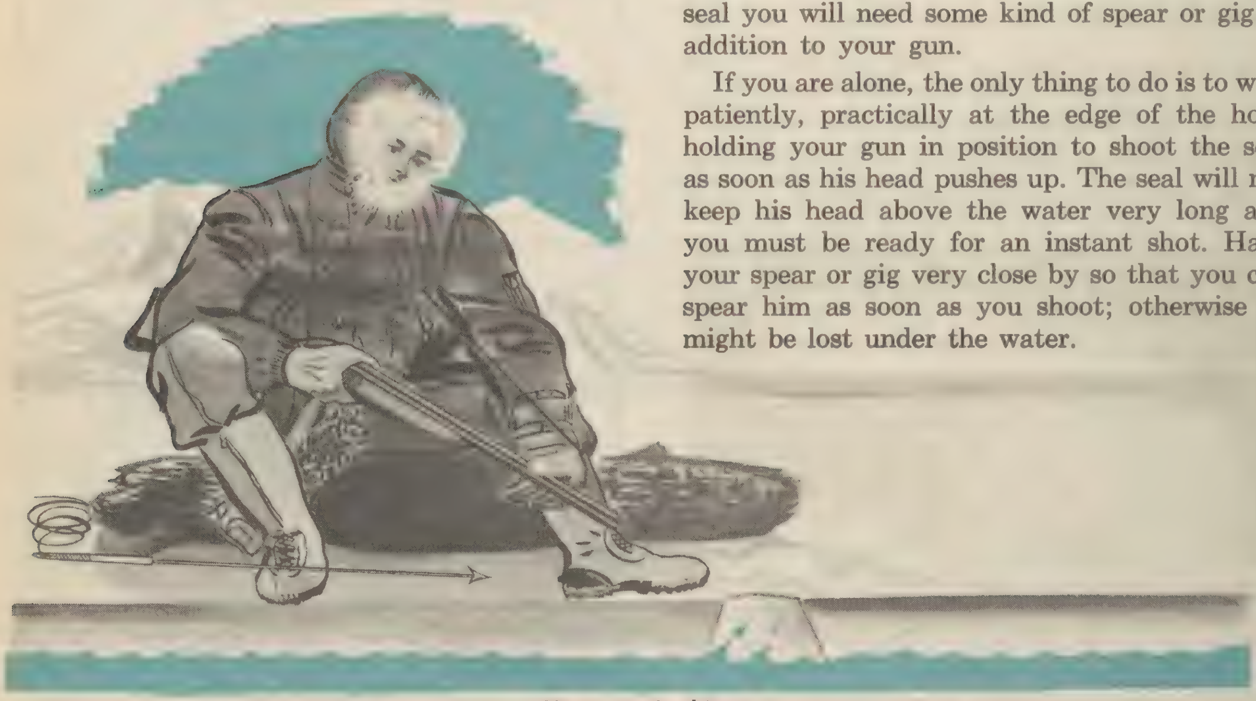
April. When hunting seals, stay down-current from them, if possible, so the current will bring them to you. Concentrate on one animal and shoot at the head, neck, or shoulders. Seals shot in the lungs or stomach usually escape.

Another method of getting seals in the summer and autumn is to catch them in coarse nets made of strips of animal skin or rope with a mesh about nine inches square. The nets are usually floated across narrow channels through which seals are known to pass. An all-service, large-meshed net may be equally good for catching seals and young white whales.

In the winter the best place to hunt seal is in openings in the pack ice—that is, leads. You will frequently find quite a number of seals at the leads and they will be easier to shoot there than at their breathing holes. Carry along your fishing line, hook, a weight, and cork. You will need these in order to retrieve your seal—the weight in order to be able to throw the line far enough, and the cork to keep the hook afloat on the water. After you have killed the seal, toss the line, weight, and cork over the lead on the far side of the seal. Then gradually pull the line until the hook is near the seal, jerk it slightly to catch in the seal's skin, and pull the seal over to the edge of the lead where you can retrieve it. If you are careful, even a small hook will do the job.

Shooting seals at breathing holes and retrieving them is much more difficult and requires considerable patience. Generally, seals make a number of breathing holes within a fairly small area and when you find one hole you can be relatively sure that there are others in the vicinity. These holes are depressions in the center of little mounds of ice built up over the surface. The mounds result from the fact that each time a seal comes to breathe at the hole he has to break through the ice that formed over the hole since the last time he breathed there, and this ice gradually piles up around the hole to form a mound. To kill and retrieve the seal you will need some kind of spear or gig in addition to your gun.

If you are alone, the only thing to do is to wait patiently, practically at the edge of the hole, holding your gun in position to shoot the seal as soon as his head pushes up. The seal will not keep his head above the water very long and you must be ready for an instant shot. Have your spear or gig very close by so that you can spear him as soon as you shoot; otherwise he might be lost under the water.



Hunter at Seal Hole.

If there are a number of crew members hunting together, locate all the seal's breathing holes in a given vicinity and place one man equipped as previously described at a centrally located breathing hole. Then have the others stomp about at each of the other holes so that the seal will have only one breathing hole at which to come up. This will make it more likely for the seal to come up at the particular hole being guarded.

In the spring, seals lie on the surface of the ice next to their breathing holes and bask in the sun. A basking seal is hard to approach and, unless killed instantly by a shot in the head, it slips down into its hole and is lost. Approach the seal by pretending you are a seal also. Eskimos know that seals lying on the ice sleep in a series of short naps, generally lasting about a minute or less, separated by quick glances about. So the Eskimo lies flat on the ice and gradually works closer, moving forward while the seal naps. Should the seal see him moving and become fidgety, the Eskimo raises his head and looks around as a seal does. The chances then are that the seal will mistake the hunter for another seal and will no longer be worried. However, you should observe two rules. One is not to dress in white, for if you do the seal might mistake you for a polar bear, become frightened, and leave the spot. The other is not to approach the seal directly.

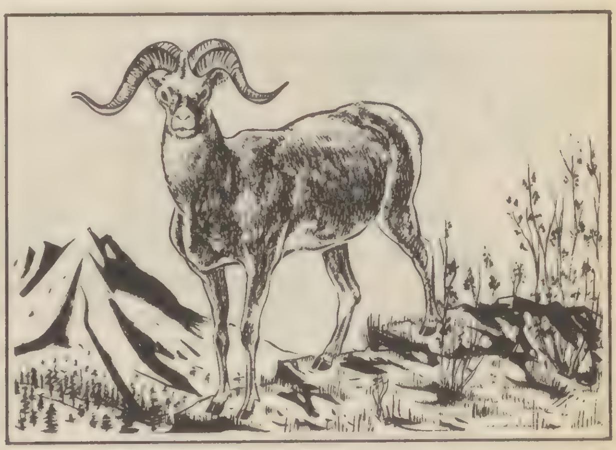
The fresh liver, heart, and kidney of the seal are choice parts, exceptionally rich in food value. You can make the oily flavor somewhat less pronounced by carefully removing the blubber and blood from the meat. The blood is edible, however, and you should save it. Eskimos sometimes eat the liver raw, fresh from the body. You will prefer it broiled or fried. If you broil seal meat, put some fat with it. The easiest way to prepare it, though, is to cut off chunks and put them in water to boil. Don't boil the meat too long because that destroys the vitamins. By putting blubber in with the meat when you boil it, you can get a pressure-cooker effect, for the fat will form a layer on top of the water that will act somewhat like a sealed lid.

Before you store seal meat, carefully remove the blubber; otherwise it will turn rancid and will not be fit to eat.

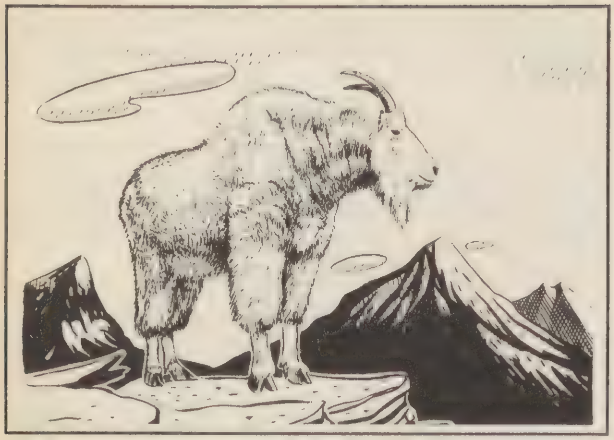
POLAR BEARS. Unless you have a powerful, high-velocity, big-game rifle, it is not a good idea to hunt for polar bears. Bears are hard to kill and a wounded bear is very dangerous. Of course, it is possible that the bear will approach you, for polar bears, as well as brown, grizzly, and black bears are born raiders and may be quite aggressive. In that case, shoot the .22 caliber barrel of your survival gun to sever the spinal column, cut an artery in the heart, or penetrate the brain. If this fails, wait until the last possible moment before firing the .410 barrel. If you fire it into the bear's face at point-blank range, say at 8 to 10 feet, it will stop or blind him.

MOUNTAIN SHEEP. If you are stranded in the mountains of Alaska, mountain sheep (bighorn) may be almost your only source of meat. Because the sheep are usually found high up on the slopes, hunting them usually means stalking and long shots, and retrieving your game may be hazardous. The hunt is never easy but it may help to remember that all mountain sheep are less suspicious of anything they see or hear above them than of what they see or hear below.

*Polar bear.*



*Mountain sheep.*



*Mountain goat.*

*Wolf.*

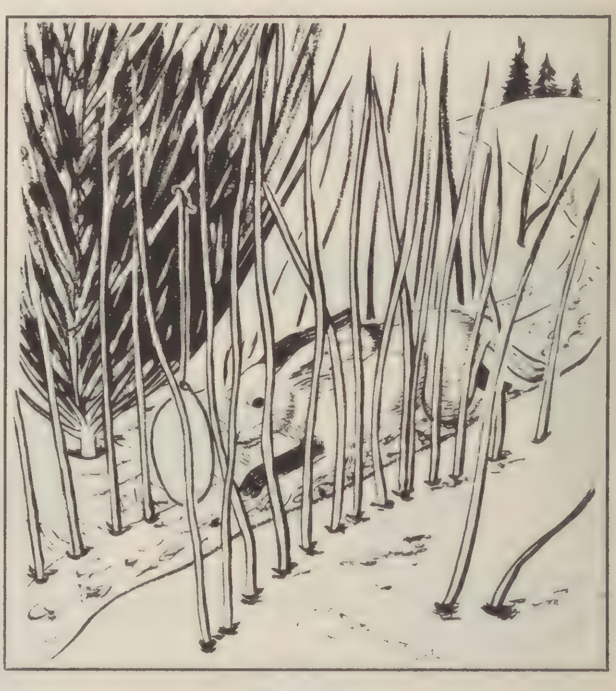
MOUNTAIN GOATS. The goat is not as good to eat as the mountain sheep, but meat is meat when you are hungry. Furthermore, the goat is not very difficult to stalk, once you have climbed up to the goat zone.

WOLVES. The wolf is edible, and its fur may be used for clothing. It is almost sure to be found wherever there are caribou or reindeer. Being clever, it may rob a trap line for weeks at a stretch without allowing itself to be seen by the trapper.

FOXES. Fox meat is edible. The fur is warm but not durable; hence it is not usually used for clothing. Foxes are keen-eared and curious. Conceal yourself well and lure them out for a good shot by vigorously kissing the back of your hand in imitation of a wounded bird or mouse. Or you can make a fox-trap by building up a dome-shaped structure of stones or snow-blocks, about eight to ten feet in diameter, five feet high, and open at the top. The walls should slope in strongly. Bait the trap with a chunk of meat. The fox will climb the structure, jump into the trap from the top to get the meat, and then will be unable to get out.

HARES. Hares are common in the polar regions. The simplest method for getting polar hares is to hunt them with a rifle. Firing a gun along a cliff will sometimes set a dozen hares running. A running hare is a tricky target; do not waste ammunition on it. But a sharp whistle often halts the hare just long enough for a successful shot. You can snare hares easily in clumps of shrub willows where they feed. Set your snare either along a used runway or in thick shrubbery in a willow clump. You can make a simple snare by attaching a wire noose to a growing twig. Make a passage by thrusting a stick into the earth opposite this twig, and run a fence of sticks out from these two main pillars so that the hare is forced to use the opening. The noose (about $4\frac{1}{2}$ inches in diameter) should hang in the opening and should be from six to eight inches above the ground at its base. Try to visit your snares at least twice a day. If you do not, a fox may eat your catch.

When you eat hare, be sure to eat its blubber or other fat as well. Hares are rarely fat, and you need fat in the polar regions. Although you will lose weight steadily on a continuous diet of lean hares, it is better to eat hares than to starve to death.



*Hare snare.*

MARMOTS. The hoary marmot, a woodchuck like animal, is good-sized and makes excellent food. In late summer, before hibernation, it is very fat. You can catch a marmot in a steel trap set at the mouth of its burrow, or you can shoot it. Do not fire, however, until it is some distance away from its den and is perched on a boulder. In the summer, if you have no gun, cut it off from its burrow. It will run straight past or over your feet and you can kill it with a stout stick or a stone.

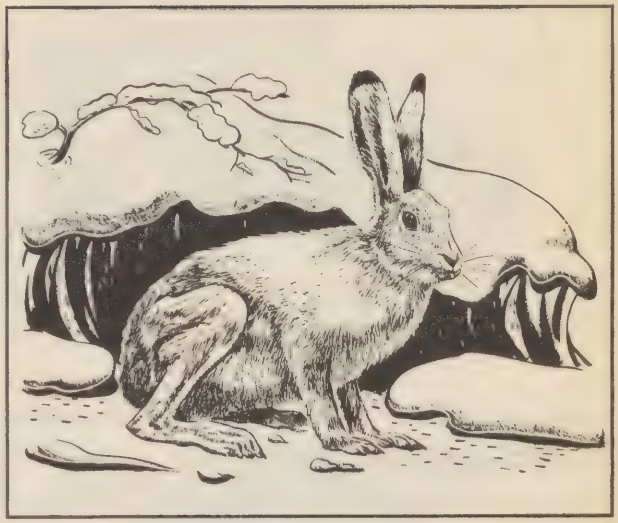
LEMMINGS. If you cannot get larger game, you might have to eat these polar mice. In summer, look for lemmings under rocks or scuttling along their runways in the moss or grass. You can often catch them with your hands. In winter, their nests are on or near the ground, deep in snow drifts. You can catch them by setting snares of very fine wire along their winter runways, but be sure to cover completely the cutaway parts of the burrow where your trap or snare is set, because lemmings seem to avoid light. Another difficulty in trapping these animals is that shrews, weasels, or other lemmings may eat your catch.

PORCUPINES. The non-hibernating porcupine ranges northward to the very limit of trees, reaching even in northern Labrador where animal life is scarce. It often sleeps high in a tree curled up near the trunk. Kill procupines with a club and save your ammunition. Be careful of the spines.

MUSKRATS. These rodents range northward to the tree limit. They inhabit streams and marshes and build a moundlike house of grass, with an entrance below water. If you open this house quickly, you may surprise a drowsy animal, or, in late spring or summer, find a brood of young. In winter, it may be worth your while to follow a fresh muskrat track that leads away from water—muskrats sometimes wander into the uplands where they can be caught easily.

SQUIRRELS. The red squirrel lives in the evergreen woods of Canada and Alaska. It doesn't hiberante. To lure it close for a shot, stand still a moment, then start kissing the back of your hand loudly.

Westward along the Arctic Ocean from Hudson Bay, you may be able to get a ground squirrel during summer (but not in winter, for it hibernates) with a snare placed at the mouth of its burrow or with a simple deadfall made of a flat,



*Hare.*

*Marmot.*

*Squirrel.*

*Porcupine.*

*Muskrat.*

heavy stone propped up with a short stick and baited with grass, grain or other food.

OTHER ANIMALS. The beaver, mink, fisher, pine marten, otter, and Canadian lynx range well northward in wooded parts of Canada and Alaska. They are edible. Because they don't hibernate, they are a possible source of food in winter. The wolverine ranges far into the tundra, and even throughout Baffin Island. It is tough and evil-smelling, but it is edible.

Look for animals in holes in rotten standing trees. In winter, trees may be inhabited by flying squirrels, mice, and owls. In summer, woodpeckers, owls, and small mammals frequently nest in them. A big cavity in a tree near a river may contain a "goldeneye" duck's nest. Rap on rotten trees as you pass—animals may emerge from them.

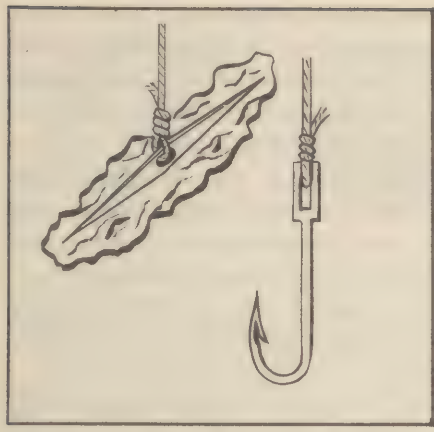
**Fishing for Food**

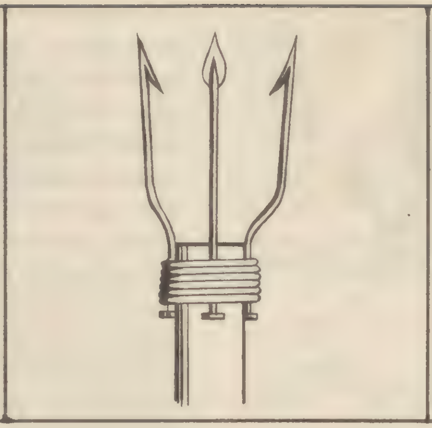
All northern fish are edible – even the ugly spiny-headed sculpin of the tidal pools. And all salt-water fish except the shark may be eaten raw—straight from the water. *Raw shark meat is poisonous.* Before you eat it, broil it several times or dry it. Fresh-water fish may contain parasites that might make you sick, so cook the fish if possible—cooking kills the parasites.

There are innumerable streams, lakes, and ponds in the polar regions, but many shallow tundra lakes have no fish of any sort in them. The only fish in some fair-sized streams are tiny minnow-like sticklebacks; and shallow rivers that teem with salmon at the spawning season may suddenly have no fish at all. On the other hand, coffee-colored muskeg streams are inhabited by fine trout that take bait eagerly—if they see it. The deeper parts of small streams are sometimes full of fish, and all tidal pools are worth fishing.

The hook and line are not your only means of catching fish. You can catch them with the same type of snare as for a hare (page 18-26). They can also be speared, shot, caught with improvised nets, or stunned with sticks or stones. In fact, in shallow water, you can even catch them with your hands.

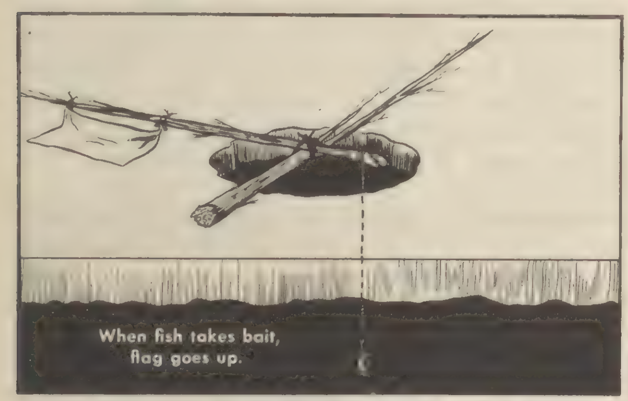
*Fishing Through Ice.*


*Fishhooks.*


*Spear.*


*Jig.*

IMPROVISED HOOKS. Lacking a real fishhook, you can make one from a nail, canned fish key, or piece of stiff wire. A soldier at Dutch Harbor caught a 20-pound halibut with a bent finishing nail and a small chunk of meat, and many an Eskimo boy has caught flounders, sand dabs, and sculpins with bent pins baited with pieces of lemming or chunks of embryo from a duck's egg. Another effective device is a fishing needle of wood or bone sunk in bait. The needle is swallowed whole, and a pull on the line swings it crosswise, causing it to catch in the fish's stomach or gullet. The needle can also be used to catch sea gulls.



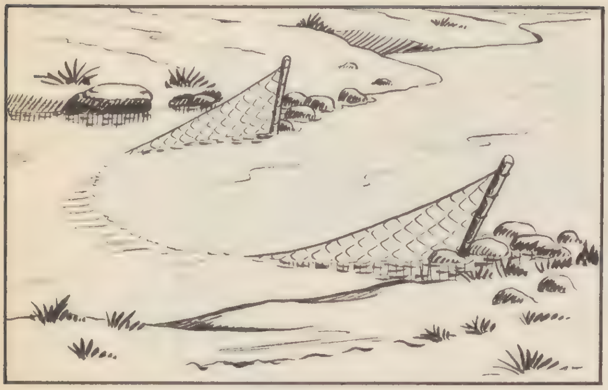
*Automatic Fisherman.*

BAIT. Don't expect to find grasshoppers in the polar region—they don't live that far north. Use any insect, piece of meat, minnow or other bait you happen to come across. Some northern fish will nibble at any small object that falls into the waters. Others, at certain seasons, pay no attention to the most tempting bait. Cod swim up to investigate strips of cloth or bits of metal or bone and can be "jigged" before they know what's happening. With a simple jigging apparatus or baited hook, salmon trout can be caught in winter through a hole in the ice of a deep lake.

JIGGING. Jigging gear consists of a hook or a cluster of hooks attached below a "spoon" of shiny metal, a bit of bone or a small weighted strip of cloth. Let the jig down into deep water, jerk it upward at arm's length, let it sink back, jerk it up again; repeat the procedure until a fish is snagged on one of the hooks. You can catch cod this way in water from a few feet up to more than a hundred feet deep. Be sure the hooks are weighted sufficiently to carry the lure rapidly downward so that it suggests something alive.

NETS. You can make a good net out of stout twine or from the inner strands of parachute shroud lines. For the full-grown salmon trout of tundra streams the meshes should be about two inches square. For such small fish as capelin, and smelts, that travel in schools, you will want a scoop net with quite fine meshes. Make one out of a pliable willow branch and netting or twine.

To make a net for stretching across a narrow channel approximately four feet wide and one foot deep, you need about twenty-six lengths of twine or parachute cord—each five feet long. Tie these in groups of two, at two-inch intervals, to any stake or metal bar two to three feet long. Keeping the rows of knots even, you begin tying the meshes, using simple overhand knots rather than square knots or grannies, and tie the loose ends to another stake or metal bar of the same length. When in place, such a net sticks out of the water a bit at either side of the channel, but the pull of the current drags the top of the net down to the surface of the water.



Fish Net.

NARROWING A STREAM. To catch fish, a shallow stream may be narrowed by building a fence of stones, stakes, or brush out from either bank, leaving only a narrow channel through which the fish can swim. Stretch a net across this channel; be sure to secure it firmly with stakes or boulders, or you'll lose both net and fish. If you have no net, you can stand ready to hit, shoot, or spear the fish as they swim past. But keep very still while you wait—fish dart away at the first sign of danger.

DIVERTING A STREAM. If you know a small stream has fish in it, try diverting its channel so as to strand the fish in pools along the old channel. This method is sometimes surprisingly successful.

TIDAL FLAT FISH TRAP. To strand fish when the tide goes out, pile up a crescent of boulders on the tidal flat. Scooping out the area inside the crescent isn't essential but increases effectiveness of the trap.

SPEARS. A good "fish-catcher" can be made from a stout stick—of about the diameter of a broom handle—with lengths of stiff wire firmly bound to and projecting from the end in such a way as to hold a fish on the bottom when it is struck from directly above. The tips of the wires need not be sharpened or barbed. If you have a drilling tool, bore holes for the wires.

A spear can be made out of a bar from an airplane tie-down kit or from any piece of metal tubing strong enough to hold it's shape in spite of the buffeting it will get. If a file is available, sharpen or barb the tip. An effective trident spear also can be improvised from materials at hand.

DOGGLING. Fish like to hide in sheltered places under rocks or along the banks, and here you can catch them with your hands. You'll have to be quick, but when you have no fishing gear and they are your only chance for a meal, keep after them. If you don't find crannies where fish are hiding, try making some for them.

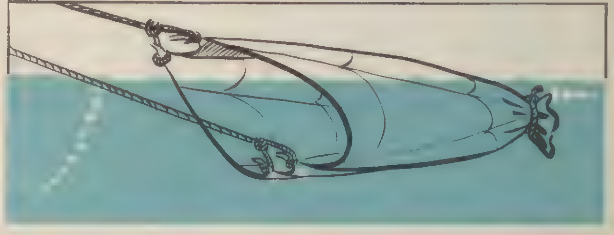
SHOOTING FISH. Don't try to shoot fish that are more than a few inches below the surface, and if you shoot from the side, aim below the fish to allow for refraction of light rays. Even with a high-powered rifle you'll be wasting ammunition if you shoot at fish two or three feet under water.

FISH IN TIDAL POOLS. Tidal pools with masses of seaweed in them may seem at first to contain no fish; poke around—you may find large numbers of small fish hiding among the seaweed near the surface and a few big ones deeper down. For the small fish you need a scoop net. For the big ones deeper down, use a sharpened pole or spear.

PLANKTON. In polar waters, one of the best sources of food is *plankton*—a conglomerate of minute sea animals, fishes, and plants which abound in polar waters. Whales and other Arctic animals, including birds, depend to a great extent on plankton for food, and laboratory tests have shown that it is high in nutritive value.

You can readily gather up plankton by dragging a conical net through the water. If you don't have a plankton net, you can improvise one from the upper part of a parachute canopy. Cut out the top to form a cone about three feet long. Tie the vent shut with a string and make a ring about 2½ or 3 feet in diameter to hold the mouth open. Then tie a bridle to it and drag it through the water. Be patient. It will take quite a bit of dragging to secure a substantial amount of plankton.

The best way to prepare plankton is to boil it and make a soup of it. But you can also eat it raw. The only disadvantage will be that, when raw, the tiny shells will stick in your teeth.

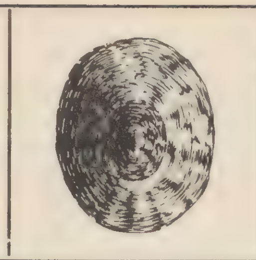


Improvised Plankton Net.

*Mussel.*

*Clam.*

*Scallop.*



*Limpet.*

*Abalone.*

**Food from the Tidal Flats**

The ocean shores of southern Alaska and the Aleutian Islands are rich hunting grounds for clams, mussels, scallops, snails, limpets, chitons, sea urchins, and sea cucumbers—all edible. These sea foods aren't found throughout the whole polar regions, but where there are stretches of open water along the shore, you are sure to find some of them at any season. Most of the makings for an emergency shore dinner can be gathered easily at low tide—and eaten raw on the spot. You can pick up a meal with your hands, dig it out of the mud with a stick, or pry it from the rocks with your pocket knife.

MUSSELS. All polar mussels are edible. However, avoid any that don't shut up tight when you touch them; they are sick or dead and are unfit for food. And beware of the black mussel about two inches long that is attached to rocks by tough threads. Along the north Pacific coast this type of mussel sometimes becomes deadly poisonous in summer (May to September). Cooking does not destroy the poison. On the other hand, this mussel can be eaten safely along the coasts of Labrador, Hudson Bay and Greenland.

CLAMS. Occasionally clams are found lying on the sand or mud, but as a rule you have to dig for them. At low tide they reveal their presence by spouting jets of water a foot or so into the air. By digging quickly where a jet shoots up, you will find the clam a few inches below the surface. You can dig with your hands, but it saves wear and tear to use a stick or empty clam shell. Clams clear their systems of sand if left in salt water a few hours, but they can be eaten raw as soon as they are dug up.

Some Alaskan clams are quite large; certain varieties are as big as your fist; one type weighs up to ten pounds. While some clams are tough, all are edible and many kinds are available.

The same poisonous organism that sometimes affects the black mussel on the north Pacific coast may also affect clams in this area from May to September. The poison can be avoided by eating only the lighter parts of clams; don't eat the black liver mass.

SCALLOPS. One of the best-eating of the mollusks is the scallop. It has a fan-shaped shell and swims free. Generally it stays offshore in deeper water, but sometimes it may be found close to shore.

LIMPETS. The limpet clings to rocks like an adhesive pad. It is about as big as a half-dollar and is covered with a single cone-shaped or cap-shaped shell. All limpets are edible, but they are rather tough, and gathering enough of them for a meal requires a lot of work.

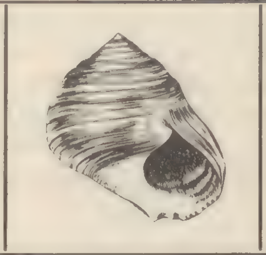
ABALONES. The abalone of northern waters never grows as large as the famous California abalone, but it has a fine flavor and is prized as food. It has a single, rather flat shell, three to four inches wide, and clings to the rocks so tightly that it must be pried loose.

TRITONS. The best-known of the northern tritons is the hairy triton. The shell of this snail is covered with a growth that gives it a plush-like appearance. Hairy tritons may be eaten raw, but the Indians prefer to cook them. They are tough and when cooked have a strong, slightly disagreeable odor.

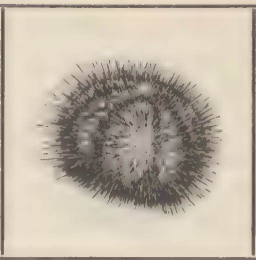
PERIWINKLES. These abundant tiny snails of northern waters are only about an inch long, so it takes a lot of them to make a meal. Put the shells in boiling water for a couple of minutes, and you'll be able to extract the meat easily.

CHITONS. Chitons are moccasin-shaped and cling to rocks tightly. When pried loose they roll up, with their hard plates protecting their soft insides. They are pretty tough but can be eaten raw. The edible portions have to be cut loose from the shell with a knife. The most palatable chitons are three to four inches long and have eight bony plates plainly visible on the back. Larger ones, with the back plates hidden under the skin, are much tougher and are not very good to eat.


Triton.


Periwinkle.


Chiton.


Sea Urchin.


Sea Cucumber.

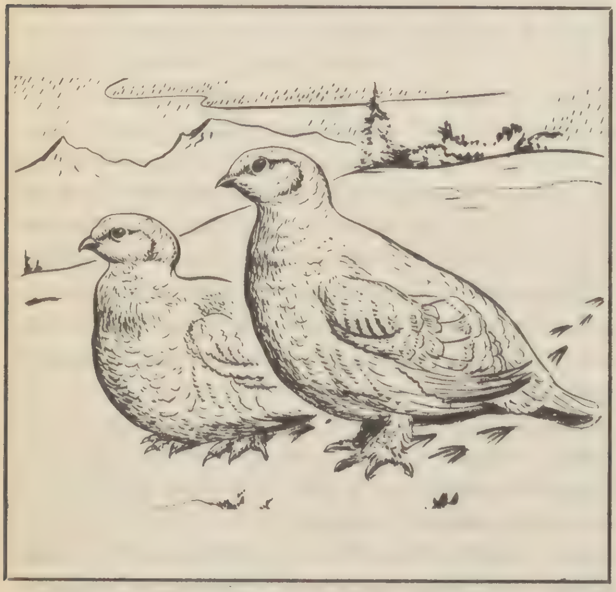
SEA URCHINS. Sea urchins are spine-covered balls several inches in diameter. They are abundant on Aleutian and south Alaskan shores, in Greenland, and in other polar waters as far north as there is land. Eat only the orange or pink egg masses. To get at the insides, poke a stick through the mouth, which is the opening on the underside. The animals are really nourishing; more than one castaway Indian or Aleut has lived a whole season on virtually nothing else.

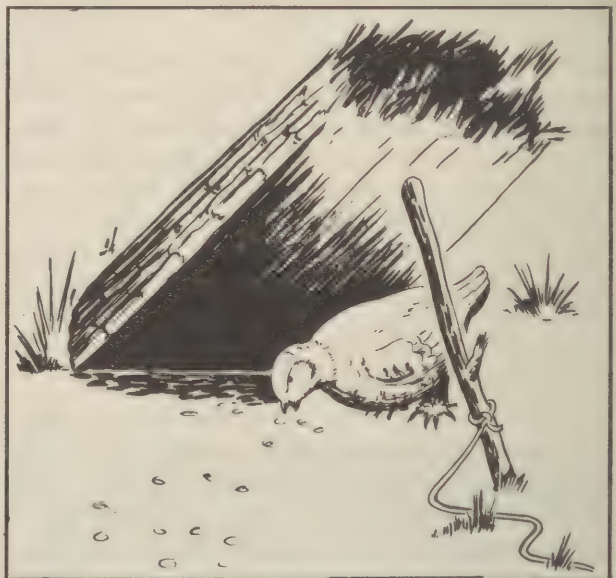
SEA CUCUMBERS. These queer-looking animals have the shape of cucumbers but are a far cry from the vegetable variety. They may be eaten raw but are much better cooked. Scrape off their slimy outer skin, cut them up, and boil or steam them.

**Birds**

All polar birds are edible, as are their eggs. Many northern birds nest in colonies that run to thousands of pairs. Near such a colony a man can keep alive all summer—even without a gun.

Ducks nest in grassy margins of ponds or on clumps of grass in marshes. If two of you are on the hunt, try dragging the ground with a rope to find the nests. When the rope passes over a nest, the sitting bird will fly off. Or try catching the mother bird with a simple trap made of your mosquito headnet, parachute cloth, or any other cloth fastened over a firm frame. If no ready-made netting is available, you can make a net of parachute cord by one of the methods described in AF Manual 64-0-4, "Emergency Uses of the Parachute" which is in the pocket of every parachute pack. Fasten the netting or cloth to two curved pieces of wire hinged together with round eyes. To set the trap, fold the net back on itself, peg the bottom firmly into the ground, and prop up the top wire with a two inch stick; the net should lie in accordion folds. Then run a long, stout cord, fastened midway on the top wire, through a low, firmly planted wicket outside the spot where the net will fall when released. The cord should be long enough to allow you to lie concealed at some distance from the trap. When


Ptarmigan.


Deadfall.

the bird takes the bait (placed at the back of the open trap), pull the cord quickly. With this trap you can get birds on the nest, birds hunting food, and ground squirrels. If large and strong enough, it will also serve for hares, ptarmigan, large gulls, ducks, geese, and swans. A trap two feet in diameter at the hinge line serves for most birds and small mammals.

After you catch the mother duck, take the eggs—whether strictly fresh or not, duck eggs are a feast for a hungry man.

Gulls can be caught with a hook baited with fish liver, entrails, or meat. Float the bait on a piece of wood. You may be able to catch a gull on the tidal flats with a rock or log deadfall. Set up a flat rock or log on a prop and put bait underneath it. Scatter bits of bait around the rock but fasten the larger chunk well back so the gull will have to go under after it. When the gull comes up and reaches for the bait, pull the prop.

For about two weeks, during the midsummer molting season, all ducks, geese, and swans (as well as many other waterfowl), lose their flight feathers all at once and become flightless. Diving ducks (such as eiders and old squaws) usually spend this time at sea; these you must get with a gun. Young eiders, geese, and swans hatched on inland waters far from the coast usually grow up there and during the flightless period are easy quarry for your shotgun. You may even succeed in catching half-grown geese and swans by hand.

The nests of auks, puffins ("sea parrots"), murres, and similar birds are on certain rocky inland or mainland cliffs in the polar regions. On Greenland's west coast, Eskimos catch the little auks with hand nets. You can take puffins at their nests dug in turf, but look out for their savage beaks. Murres are especially abundant in high cliffs such as those at Cape Wolstenholme and the eastern end of Coats Island in Hudson Bay. All these are good food because they are fat.

In summer, ptarmigan (polar grouse) are so well camouflaged with protective coloration that they are hard to see, even when they are running. In winter, they are white, with black tail feathers that show only in flight. Ptarmigan are found both in low country and on ridges. In late summer and early autumn, you may come on broods of unsuspicious young; these you can kill with stones. Willow clumps are good places for ptarmigan snares.

Slingshots are excellent for killing ptarmigan, other birds, and small game. A powerful and durable slingshot can be made of one of the two-foot metal rods from your plane's tie-down kit (or any similar metal bar), two twelve- to fourteen-inch lengths of elastic shock cord, a piece of webbing or belting from the material in which the parachute is packaged, and some fine copper wire.

To obtain the greatest food value from birds, pluck rather than skin them. If you can, pluck geese and ducks while they are still warm.

## FOOD PLANTS

Food plants are found throughout the polar regions. Lichens, particularly, are almost universal. Most of the plants in the polar region are edible. Certain kinds, however, have more food value than others. Once you have learned to recognize a good food plant, study its surroundings carefully, so that you will know where to look for it the next time you need it. Watch the animals, especially birds—they will lead you to food sources you might otherwise overlook.

### Lichens

Though lichens lack flowers, leaves, stems and roots, they have possibly the greatest food value of all polar plants. Caribou live almost entirely on lichens for months at a time. Some lichens contain a bitter acid that may cause nausea and severe internal irritation and therefore should not be eaten raw. However, soaking or boiling the plants in water (if possible, with a pinch of soda) removes the acid. If you cannot cook them, simply soak them overnight, pour off the water, and eat the residue. However, lichens taste better when boiled. Do not be repelled by the gelatinous appearance of boiled lichens.

Lichens are most palatable if prepared as a powder. Soak them over-night, then dry the lichens till they are brittle. You can make them crisp by roasting them slowly in a pan. Afterwards, powder the dried plants between your palms or pound them with a stone. Soak the powder a few hours, then boil it until it forms

## WARNING

There are only a few polar plants that are poisonous. Learn to know them, for they are dangerous.

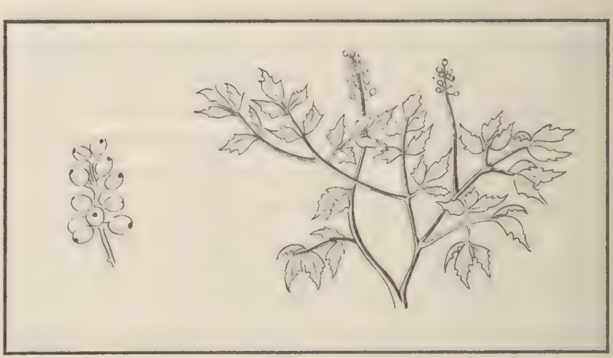
## WATER HEMLOCK

This plant belongs to the parsnip or carrot family, as the leathery, toothed leaves, and small flowers arranged in clusters suggest. The leaves are streaked with purple and when crushed emit a disagreeable odor. Do not eat any part of this plant or plants similar to it, even though the parsnip-like roots look inviting.


*Water Hemlock.*

## BANEBERRY

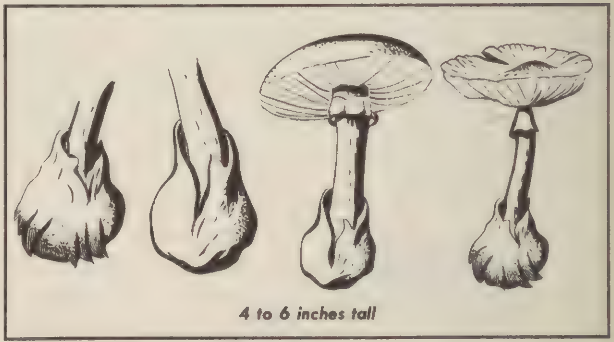
You can easily recognize a baneberry by the cylindrical cluster of red or white berries borne at the tip of the stem. The berries may turn blue as they get older. The baneberry grows throughout the wooded areas of Alaska and Western Canada. Do not eat it.



*Baneberry.*

## DEATH-CUP AMANITA

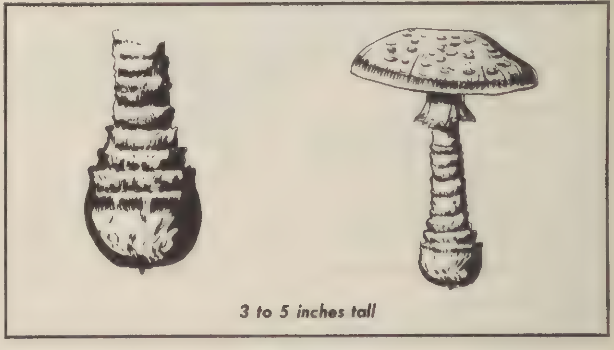
This mushroom occurs in damp forests. Usually, it is completely white, but the cap may have tints of orange, purple or brown. When fully grown, the cap is four to six inches wide. When young, it is steeply convex on top, but later it flops downward from the center like an inverted saucer. The surface is sticky when moist. Beneath are white gills attached to the underside of the cap, but not to the stem. The stock is white and brittle and has a spherical base that is buried beneath the ground and that rests in a soft white cup which is not visible until the entire plant is exposed. This plant is poisonous.




*Death-Cup Amanita.*

## FLY AGARIC

This is a handsome mushroom with a yellow, orange, or red mottled cap, whitish or yellowish scales, and white gills. When these fungi are young, they may be mistaken for puff balls. However, breaking them discloses the gills.




*Fly Agaric.*

## EMETIC RUSSULA

This mushroom usually grows in the woods. You can recognize it easily by the top of its "umbrella", which is pink or rosy when young, and red or yellowish when older. If you eat this mushroom, it will probably make you vomit; hence its ill effects are neither serious or lasting.

No plants of the polar or sub-polar regions are seriously poisonous to the touch. A few, however, such as *ladyslipper,* and *devil's club* are irritating to some people. So do not touch them.


*Rock tripe.*

a jelly. Use this jelly to thicken soups and stewed vegetables, or cook it with meat, especially if meat is scarce, for the lichen jelly will stretch it out. A mixture of flour and lichen powder may be used as a base for nutritious biscuits.

Rock tripe is a lichen consisting of thin, leathery, irregularly shaped discs, one to several inches across, and black, brown or greenish in color. The discs are attached to rocks by very short central stalks. They are soft when wet but hard and brittle when dry. Iceland lichen is dark brown, bushy, coral-like plant with individual straplike "branches" that have hairy edges. It grows in dense colonies on sandy soil. When properly cooked, this lichen is palatable and nourishing. Reindeer lichen is a grayish, many-branched, coral-like plant that prefers hollows or slopes with winter snow cover. It is as nutritious as Iceland lichen. Northern hunters make a stimulating tea from it.

**Berries**

All berries except the baneberry are edible, and berry bushes are abundant. The bushes are low-growing; sometimes they form mats. Despite their small size, individual bushes are good producers. Frequently berries remain on a bush throughout the winter, and the following year are even sweeter than those of the current season. If you wish to preserve the berries, freeze them into bricks; freeze them quickly and thoroughly. Start the process right after you pick the berries in order to preserve maximum food value.

The mountain cranberry (lingon) is a low creeping shrub with leathery evergreen leaves. It grows best in open birch or willow thickets and has red berries that are high in vitamin content.

The blueberry is a low shrub with small oval leaves that drop off in winter. It grows in open places. The berries are blue to blue-black.

The cloudberry (salmonberry or baked-apple berry) has small maple leaves. Its berries, which resemble raspberries, are reddish when immature but yellow when ripe. The raw berries are somewhat laxative. Their flavor is much improved by cooking.

The crowberry is one of the most abundant and widespread polar plants. Its slender leaves resemble fir needles, and its berries are shiny black. It grows along shelves on rocky ridges and hills where the snow is not deep, and therefore can be found even in winter.

The alpine bearberry is a trailing shrub with shreddy bark and round-tipped leaves that turn bright red in autumn. The berries are black or red and are rather tasteless. Related to this is the

*Mountain cranberry.*

*Blueberry.*

*Cloudberry.*

*Crowberry.*

*Alpine bearberry.*


**Sweet vetch.**


**Lousewort.**

**Fungi.**


**Bistort.**

red bearberry (kinnikinick), with coral-red berries that are somewhat mealy and tasteless when raw but very nourishing and palatable when cooked. The dried and shredded leaves make a fairly good substitute for tobacco.

The cranberry occurs in similar marshy areas and on shaded upland ledges, particularly where peat moss (sphagnum) occurs. The berries are red and may be rather sour.

**Edible roots**

Several polar plants have roots that store energy-giving starches. All these roots are called *masu* by the Eskimos. To get the roots you will need a digging tool, unless you can succeed in stealing them from the underground runways near the surface, where they are stored by meadow mice. Eskimos use dogs to nose out the caches. Even though you have no dogs, try to spot these stores and save yourself a lot of digging.

The commonest root is northern sweet-vetch (licorice root) which grows in clumps on sandy soil, especially on lake shores or along streams. It has pink flowers similar to pea or clover flowers, while its leaves resemble those of locust trees or the famous locoweed of our western states. Learn to recognize the leaves so you can find the roots when there are no flowers. The cooked root tastes like young carrot but is even more nourishing.

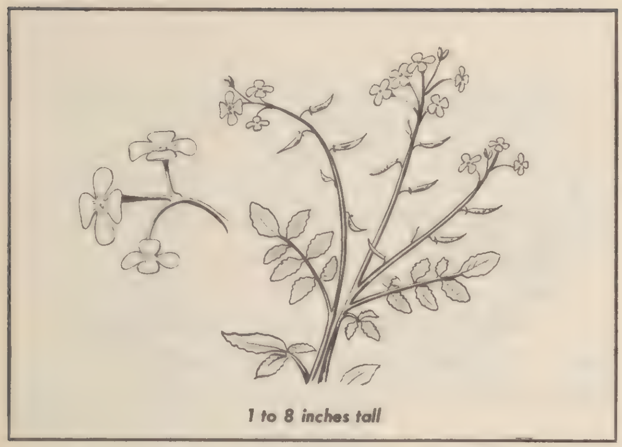
Another valuable root is that of the woolly lousewort which grows in dry tundra. Flowers of this plant are rose colored, resembling those of the licorice root in shape but arranged in denser clusters. The flower stalks are thick and strong and are visible long after the flowers have dropped off. During the winter, the leaves and flower stalks may be visible above the snow. The sulphur-yellow root is large and sweet. It is edible either raw or cooked.

Bistort or knotweed, also common in dry tundra, has small white or pink flowers that form slender spikes. The elongated smooth-edged leaves come out from the stem near the level of the soil. The root is about the size of a pecan, and is rich in starch. The slightly acid taste of the raw root disappears when it is cooked. Soak it in water for several hours and then roast it.

Kamchatka lily (saranna) grows in meadows and among low shrubs along the Pacific coast of Alaska and on the Aleutian Islands. Its flowers are shaped like other lily flowers. The stem rests in a large bulb surrounded by small bulblets about the size of rice grains. The bulbs serve as potatoes for the natives of Kamchatka because they contain large amounts of carbohydrates. People have lived solely on this bulb for long periods. Roast the bulbs in coals or boil them. Dried and powdered bulbs make good bread, soup, or porridge.

**Antiscurvy Plants**

Scurvy has taken its toll of men in the polar regions. This dread disease results from vitamin C deficiency and may be brought on by prolonged diet of canned or lean meat and no vegetables. Most plants yield some vitamin C, but several are notably rich in this antiscurvy vitamin. Among these is "scurvy grass", which occurs along sea beaches. It has small white flowers and globular fruits; the lower leaves, borne on short stalks, are kidney-shaped. All parts of the plant are somewhat fleshy. The leaves, stems, and fruit, eaten raw, are valuable antiscurvy food.


1 to 8 inches tall

*Scurvy grass.*


8 inches tall

*Sourgrass.*

Spruce twigs and leaves are also rich in vitamin C. Black and white spruce occur throughout the sub-polar forest and, in general, reach farther north than any other evergreen trees. They have short stiff needles borne individually, not in clusters as are pine needles. The cones are only one or two inches long and have thin scales. Black spruce cones are globular, while those of white spruce are slightly elongated. A strong infusion prepared by boiling young twigs and leaves in a covered pot, prevents and cures scurvy. The buds, needles, and stems, have a strong resin taste, but give some anti-scurvy vitamin C when chewed raw.

The fresh green leaves and inner bark of the dwarf polar birch also are high in vitamin C. You can distinguish the birch from its companion shrub, the willow, by its thinner leaves and peeling bark.

**Greens**

Several polar plants are fairly good substitutes for the leafy vegetables of our civilized diet. Some of these plants contain vitamins and minerals, and all of them give bulk to your diet.

An important green is wild rhubarb (alpine fleece-flower) which grows on open river banks and recent landslides. The stems are reddish and, like cultivated rhubarb, bear pointed leaves with wrinkled edges. The flowers form scraggly clusters. The young stems are bright red and juicy. When cooked, they resemble rhubarb in flavor.

Another green is sourgrass (mountain sorrel), which lives on moist, shady slopes and in ravines. Its fleshy, kidney-shaped leaves are borne on long, slender stalks, and its red or green flowers are arranged in plumelike branching clusters. The leaves and stems taste somewhat acid when raw but are very refreshing. When cooked, they resemble spinach in both flavor and appearance. New leaves are produced all summer, thus supplying fresh greens in any summer month.


3 to 6 feet tall

*Wild rhubarb.*


*Spruce cone.*


4 to 8 inches tall

*Willowweed.*

*Dandelion.*

*Seaweed.*

Still another leafy plant is the willowweed (fireweed) which grows on sandy or gravelly soil along rivers and on beaches. It has purple flowers and fleshy, slender leaves. The leaves resemble spinach when cooked.

A woody plant in this list is the willow. This is the "tree" of the polar region, yet it often looks anything but tree-like because it grows close to the ground and spreads out like a cushion. Its cottony seeds are conspicuous during the spring when they are ripening and blowing around. The young, tender willow shoots contain a large amount of vitamin C and may be eaten as greens. They have a decidedly sour flavor.

Dandelion, a weed pest in the United States, is a potential lifesaver to anyone stranded in the polar regions. The young leaves make fine greens. Cook them only a short time, and bear with their bitter taste. Both leaves and roots can be eaten raw.

Marsh marigold is found in swamps and along streams and is one of the earliest plants to come out in the spring. The leaves and stems, particularly of young plants, are delicious when boiled.

Cow parsnip is abundant on the Pacific coast of Alaska and on the Aleutian Islands. Its large size and characteristic flower cluster make it conspicuous. The entire plant dies down to the ground each winter. Cow parsnip resembles the poisonous water hemlock of the sub-polar forest. Both plants belong to the same family and have very similar flower clusters. The leaves, however, are entirely different. Learn the difference so that you can tell the plants apart. The young shoots and leaf stalks of the cow parsnip are edible either cooked or raw. Leaf stalks that have rusty or reddish spots or streaks are better than solid green ones. If there is no fresh water available, chew the leaf stalks of the cow parsnip. They will quench your thirst because they contain much water.

### Seaweeds

Seaweeds should be on your menu whenever possible, especially if you eat much fish. They contain valuable vitamins and give bulk to your diet. In fact, they do the same thing for

*12 to 20 inches tall*

*Marsh marigold.*

*3 to 8 feet tall*

*Cow parsnip.*

your emergency rations that lettuce, cabbage, and many other foods of little food value do for your normal diet. The bulk they give helps prevent constipation. The gelatinous consistency of cooked seaweed may offend your senses of sight and taste, but it is just what you need to round out your diet. Indians, Philippinos, Hawaiians, Chinese, and many other peoples have eaten seaweeds for centuries.

Three kinds of seaweed are common:

Brown ribbons, several inches wide and amazingly long, which float in the surf, anchored by a slender stalk.

A profusion of small, brown, branched forms which make a jumbled mass on the rocks exposed at low tide.

Very thin green, wrinkled sheets of "sea lettuce" which grow on rocks, driftwood, other seaweeds, and on mud flats in quiet bays.

Take care in the selection of seaweeds for your stew pot. Fresh, healthy specimens have no marked odor or flavor and are firm and smooth to the touch. If the plant is wilted and slimy and has a fishy smell, it is decaying and should not be eaten. The large, brown, ribbon-like seaweeds can be either minced and eaten raw, or dried, shredded and scattered over other food. Discard the stalk and other tough parts; eat only the tender portions. The coarser red seaweeds are best if cooked; they are gelatinous and are most palatable if used with fish to make a stew. The broad-leaved "sea lettuce" is good chopped and can be eaten raw or stewed. Do not eat the threadlike or slender branched forms. They are not poisonous but may contain irritating free acid. You can detect disagreeable acids by crushing a batch with your hands. The released acid causes the plant to decay so rapidly that within five minutes it gives off an offensive odor.

*Mushrooms.*

### Mushrooms

It's a good idea not to eat mushrooms. In the first place, a number of them are toxic. In the second place, they don't have much food value anyway.

## TRAVEL

Too many fliers have died unnecessarily in the attempt to leave their crashed planes and walk out to civilization. Make it a firm rule, therefore, to stay with your plane after a crash landing. Your plane will eventually be found, and so will you—if you are with it. By traveling, you not only take on a host of additional risks but you also seriously reduce your chances of being found. *Stay with the plane.*

Of course, that does not mean that you will not travel at all. You will undoubtedly have to leave your camp in order to hunt and fish, and you may have to move your camp some distance because there is no hunting or fishing in its vicinity. Even aside from hunting and fishing you will want to explore in every direction from your camp. Take progressively longer hikes each time you go out in order to find out whether there are settlements or trappers' cabins in the vicinity of your camp. Then, too, it is possible, under extremely favorable conditions, when you feel sure of your position and know definitely of a nearby settlement, and after a number of weeks during which there were many days of good flying weather, that you will decide that for some reason they missed you and feel that you might have a better chance by walking out. Learn the principles of travel, therefore, so you can take care of yourself when the need for travel arises.

Whatever you do, and regardless of how far you travel, never start out when the weather is bad. If you travel for any considerable distance, lay careful plans and make thorough preparations for your trip. Destroy all classified documents and secret equipment before you go, and leave a written message at the airplane describing your planned route.

#### Selection of Route

If you know approximately where you are, decide on a destination and stick to it. Then choose the mode of travel. The conditions of the party will be a determining factor. If some of the crew are injured or are poorly equipped for travel, it may be best to float them out if possible, or to send only the best-qualified men for help. If you are near a coast or can reach one easily, head for the shore and follow it. Most settlements are on or near the coast or near large rivers or lakes. Don't follow small streams, however, for they usually wander aimlessly and lead nowhere, especially in areas underlain by permanently frozen ground.

#### Equipment

Carry only essential items. Here are a few suggestions. In summer, carry at least the following: Sleeping bag or substitute; sweater or equivalent; extra socks; mosquito headnet; gloves; matches (in waterproof case), candle, solid fuel, or other fire-making materials; axe; first aid kit; emergency food (in waterproof container); canteen; compass; goggles; knife; logbook and pencil; map; watch; tent or substitute; improvised pack; fishing tackle; wire for snares; gun and ammunition. In winter, carry all the summer equipment (except mosquito protection) plus winter clothing and equipment. Check your equipment and supplies before you pull out and make a daily check before breaking camp to see that nothing is left behind.

#### Improvised Travel Aids

Look at the airplane with an eye to improvising travel equipment from it. For example, the engine cowling will make a sled. Your parachute can be useful in many ways. What remains after you have made a tent of the fabric is material for a parka, sleeping robe, or foot wrappings. Shroud line can serve many purposes. Carry plenty of it with you. The inner threads will make a fish line and sewing silk. There are potential fishhooks and sewing needles in K-ration can openers. Make a pack of a pair of pants or a pack-strap of your parachute harness. Secure a travel staff by pulling out a 5- or 6-foot section of metal fuel line or make a staff from a branch of a tree.

#### Travel Technique

Take it easy, and set a slow pace at the beginning, but keep going—except for five- to ten-minute rests every forty-five minutes or so. Don't drive yourself beyond your strength. Start as soon as it is light (weather permitting) and camp early in the afternoon. Halting early gives you plenty of time for making camp, drying clothes and fixing the evening meal—which should be your biggest daily meal.

Mark your trail. Leave signs—such as rock piles, blazed trees, or lopped off trees—along your route in case you have to make a return trip. Use the types of markers that will be visible from as far away as possible. A blazed trail will help a search party also.

Keep together. Getting lost is usually the result of splitting up a party. Stick together and adjust your pace to the slowest and weakest man. Don't crowd on the trail—keep eight to ten feet from the next man.

Always take the safest and easiest way, even if it is sometimes longer. Climb steep hills at a slant, zig-zagging back and forth if necessary. Avoid loose rocks and gullies. Look ahead for reflections of land or sea on the undersides of clouds; snow-free terrain, timber, and open water show up as black areas; ice casts a more or less mottled reflection; and snow, a white one.

A compass is helpful in direction finding, but be sure you know the magnetic declination (variation) in the Far North—it may be very large. Keep your watch going and note the time you reach landmarks. Try to estimate your rate of travel and plot your course. There are certain natural signs that aid in telling direction. You can estimate direction even in a dense fog by the orientation of snowdrifts.

To avoid walking in circles, a common problem in trackless wastes, pick an object in the distance and walk toward it. When you reach the object, pick another, in the distance, checking back to the point from which you came to make sure that you're advancing in a straight line.

In case you get lost or must double back, always take note of unusual and distinctive features in the landscape. Think back to where the mistake could have occurred. Analyze the situation and keep calm. Look for landmarks. Return by your out-going trail. In case of fog or darkness, camp and wait for good visibility. Above all, keep dry and warm and get enough sleep—you'll need all your strength. Make signal fires or other signs at each campsite.

Make camp early when you find a place that offers fuel and natural shelter; organize work crews—assign set tasks to each man; it will make camping operations quicker and easier.

CROSSING STREAMS. In winter or summer, rivers are the best highways in the polar regions, but cross them cautiously. In fording a swift stream during summer, wade upstream and poke ahead of you with a pole. In very fast water, carrying a weight—such as a stone—sometimes helps you to keep your balance. If you have a rope, the first man to cross should be roped so that he can be pulled out in case he should lose his footing. After crossing, he should make the rope fast for the rest to use as a support.

During thaw and when fording glacier-fed streams, cross in the early morning before melting has swollen the streams. Where the current is swift during winter, ice may have thin spots. Distribute your weight by wearing snowshoes if available—even if the surface is hard and you don't need them for support. Otherwise, lie down and crawl across. Be especially careful in crossing snowdrifts that bridge streams. Sound ahead with a pole. When crossing ice, occasionally test for thickness with an axe or knife.

Be particularly careful in fording glacial streams. The beds of these streams are of glacial silt, which is very finely ground rock and acts like quicksand. The same is true of the mouths of all polar rivers. Muskeg, likewise, is dangerous in many places because it acts like quicksand.

GLACIER TRAVEL. Glaciers are characteristic of the polar mountainous regions. They cover all but a narrow coastal fringe in Greenland and are widespread in the high ranges of northwest Canada and Alaska. Glaciers, like rivers, provide natural avenues of travel, but they must be traversed with caution. Glaciers are composed of moving ice, the surface of which is smooth or broken into a pattern of crevasses.

As long as the surface of the glacier is free of fallen snow, crevasses and other obstructions are obvious and can be avoided with normal care, but, according to altitude and season, a layer of

snow may cover the ice surface and bridge the crevasses. Proceed with extreme caution on snow-covered glaciers if there are less than three of you. Members of a party should be roped at intervals of thirty to forty feet. If you are traveling alone you can reduce the danger somewhat by tying loops at every two feet into the line by which you pull your sled. In this way, if you happen to fall into a hidden crevasse which is too narrow to permit the sled to fall through, you can climb back up the tow rope. Obviously, even with this system you must proceed with extreme caution, sounding with your travel staff as you go along.

The trend of a hidden crevasse will be visible commonly as an elongated depression in the snow surface, and breaks may be present in bridges at their weakest points. Always cross a bridged crevasse at right angles to its trend. Select the strongest part of the bridge by probing with an ice axe or a pole. Avoid traveling parallel to the trend of a crevasse, but if it is necessary in searching for a strong bridge, the leader, while probing, must direct his party to follow a course paralleling his own as far back from the crevasse as the rope interval permits. When crossing a bridged crevasse, distribute your weight as much as possible—by crawling or by wearing snowshoes or skis (if available).

Travel by water. Summer travel over rough or swampy terrain is arduous. Therefore, attempt to make your way by water. If possible, use the life rafts from the plane, or improvise a boat or raft. If pliable wood is available, you can make a boat by wrapping a tarpaulin around a framework. You can contrive rafts of tire tubes and tanks or other tight containers. Dry driftwood is another possibility for raft-making—use parachute shroud line for lashing. Assemble log rafts close to the water so they can be launched easily. In shallow water, propel the craft with a long, smooth pole; in deeper water use an improvised paddle hewn from a small tree. As you float downstream, keep on the lookout for mist or spray ahead—the sign of rapids or waterfalls. When this warning appears, pole or paddle to shore and look the situation over. If the going is dangerously rough, get out and let your craft down to smoother water, checking it with a rope. You can make a good rope by tying or twisting together several shroud lines.

### Native Help

Keep your eyes open for native Eskimos or Indians. They are your best bet for getting out safely; once you meet them, your battle is practically won. They know the country, its trails and waterways, its available foods, and the way back to civilization. All the polar peoples are friendly, if you approach them with friendliness, courtesy, patience, and common sense.

## ESKIMO DICTIONARY

Here are some words and phrases used throughout most of the polar regions—from Greenland and Labrador westward through northern Alaska. They are spelled to show pronunciation. The accented syllables are in caps. Whether a phrase or word is a declaration or a question depends on the inflection you use, just as in English.

| English | Eskimo |
|---|---|
| **CALL FOR HELP** | |
| Hey there! (help) | *Ah—HOY—la!* |
| **GREETINGS** | |
| How do you do | *Auk—shun—EYE* or *CHIME—oh* |
| **I AM** | |
| I | *Oo—VUNG—ah* |
| I am cold | *Oo—VUNG—ah ICK—key* |
| I am wet | *Oo—VUNG—ah COW—shook* |
| I am hungry | *Kah—POONG—ah* |
| **YOU ARE** | |
| You | *IG—vee* |
| **I NEED** | |
| I need or I want | *Pee—you—mah—VUNG—ah* |
| I want a drink | *EE—mick pee—you—mah—VUNG—ah* |
| I want some food | *NER—key pee—you—mah—VUNG—ah* |
| I need dogs | *KING—mit pee—you—mah—VUNG—ah* |
| I need a dog sledge | *COMMA—tick pee—you—mah—VUNG—ah* |
| **COURTESY** | |
| Thank you | *MUTT—nah* or *KWA—na* or *Koo—YENNA—meek* |

If an Eskimo has been awkward in helping you or has been unable to help you, soothe him by saying:

| English | Eskimo |
|---|---|
| It doesn't matter | *Koo—YAN—nah* or |
| It can't be helped | *MOM—e—ana* |

Your acceptance of day-to-day troubles without too much show of emotion will appeal to Eskimos.

| English | Eskimo |
|---|---|
| **CLOTHING, EQUIPMENT AND FOOD** | |
| Boot | *Comic.* Pronounce it exactly as you would the English word *comic.* In the plural, the final *c* becomes a *t,* so boots are com-it. |
| Clothing | *AH—no—wah—ga* |
| Blouse or parka | *KOO—lee—tock* |
| Snow house | *IG—loo* |
| Snow-knife | *PAH—na* |
| Seal-oil lamp; Eskimo stove | *KOO—di—lick* |
| Match or fire | *EE—ko—mack* |
| Gun | *COOKY—oo* |
| Tent | *TOO—pek* |
| Food | *NER—key* |
| Boat | *OO—me—ack* |
| **COMBINED FORMS** | |
| I am going | *Oo—VUNG—ah OWD—lah* (*OWD* rhymes with crowd) |
| Do you see it? or, Can you see it? | *IG—vee TAH—koo?* |
| What are you eating? | *SHOO—nah IG—vee NER—key—wah* |
| **POSSESSIVES** | |
| Your snow house | *IG—loo IG—vee* |
| Your dog | *KING—mick IG—vee* |
| Your snow-knife | *PAH—nah IG—vee* |
| My parka | *KOO—lee—tockoo—VUNG—ah* |
| Where | *Nowk* or *NAH—nee* |
| **WHERE IS IT?** | |
| Where is the house? | *IG—loo nowk?* |
| Where is your house? | *IG—loo IG—vee nowk?* |

| English | Eskimo |
|---|---|
| Where is the white man? This is virtually the equivalent of asking "Where is the trading post?" or "Where does the white man live?" | *Kab—LOO—nah nowk?* |
| Where is the river? | *Coke NAH—nee?* |
| Where is the gun? | *COOKY—oo NAH—nee?* |

### BIGNESS

| English | Eskimo |
|---|---|
| Added to nouns indicates bigness | *Ju—ak* |
| A large dog | *King—MIK—ju—ak* |
| Big snow house, big house, trading post | *IG—loo—ju—ak* |
| A big boat, hence *a ship* | *Oo—mi—AK—ju—ak* |
| Big water, hence the ocean | *Ee—MACK—ju—ak* |

### SMALLNESS

| English | Eskimo |
|---|---|
| Added to words indicates smallness | *AT—suk* or *AH—pick* |
| Little dog, hence *puppy* | *KING—mi—AT—suk* |
| Little house, hence *kennel* | *IG—loo—AH—pick* |
| Little (adjective) | *MICK—ee—you* or *MICK—ee—soo* |

### HUMAN INTEREST WORDS

| English | Eskimo |
|---|---|
| Man | *AHNG—ot* |
| Woman | *AHNG—e—nook* |
| Real man, he-man | *AHNG—o—ti MAR—ick* |
| Little woman | *AHNG—e—nook MICK—ee—soo* |
| Very useful or valuable dogs | *KING—mit MAT—ick* |

### ANATOMY

| English | Eskimo |
|---|---|
| Nose | *KING—ahk* |
| Big nose | *King—AH—ju—ak* |
| Head | *Nee—AH—coke* |
| Tooth | *KI—goot or KEY—oot* |
| Teeth | *Key—OO—tit* |
| Hand (literally, the fingers) | *AHG—sah—eet* |
| Foot | *IT—i—gak* |
| Feet | *IT—i—ket* |
| Eye | *EE—yee* |
| Ear | *SEE—oot* |
| Ears | *SEE—oo—tit* |

### YES AND NO

| English | Eskimo |
|---|---|
| Yes | *Ab* (rhymes with cob; used especially in Greenland) |
| Yes | *Ee* or *Ah—high—LAH* or *AH—mee—lah* |
| Yes, indeed! | *Ak—shoo—AH—look* |
| No | *AH—guy* or *NAH—mee* |
| No, indeed! | *NAG—gah* |

### THE WEATHER

| English | Eskimo |
|---|---|
| Weather | *SEE—lah* |
| Good weather | *SEE—lah pee—oo—YOOK* |
| Wind | *AH—no—way* |
| Bad wind | *AH—no—way pee—YUNG—i—took* |
| Much wind | *AH—no—way AH—mi—shoot* |
| Much wind today | *AH—no—way AH—mi—shoot oo—BLOO—me* |
| Much wind tomorrow | *AH—no—way AH—mi—shoot—AH—kah—go* |
| Cold | *ICK—key* |
| Cold tomorrow perhaps | *ICK—key AH—kah—go EE—mah—kah* |
| Snow tomorrow | *CONN—neck AH—kah—go* |

### ANIMALS

| English | Eskimo |
|---|---|
| Dog | *KING—mick* |
| Dogs | *KING—mit* |
| Polar bear | *NAN—ook* |
| Caribou | *TOOK—too* |
| Ringed seal, a common species | *NET—check* |
| Barbed or bearded seal, or square-flipper | *OOG—zhook* |
| White whale | *Kelly—LOO—ghak* |
| Salmon trout | *EE—mah—look* |

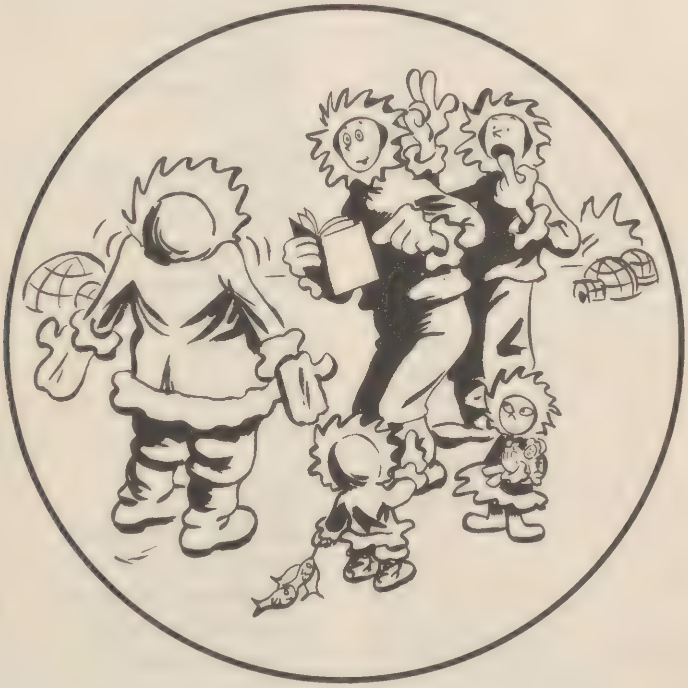
| English | Eskimo |
|---|---|
| Eider duck | *MIT—took* |
| Ptarmigan | *Ah—HIGGY—vick* |
| Snowy owl | *OOK—pick* |
| Canada goose | *NERD—look* |

## EVERYDAY WORDS

| English | Eskimo |
|---|---|
| Day | *OOV—loot* |
| Night | *OO—noo—ak* |
| Look at that! | *Tah—KOO!* or *Took—a—ROO* |
| Go ahead, now. Let's get going | *AH—tay!* |
| Wait a bit | *Watch—AIR—oh* |
| Now | *MAH—nah* |
| Come here! | *KI—geet* (Pronounce the *i* as in mice.) |
| Bring it here! | *KI—sah—geet!* |
| Ice | *SEE—ko* |
| Snow, when falling | *CONN—neck* |
| Snow, on the ground | *AH—pud* |
| Litterally, *the edge*, but used especially in reference to the ice-edge or floe | *SHEE—nah* |

## COMPLIMENTARY GOODBYES

| English | Eskimo |
|---|---|
| You are good | *IG—VEE pee—oo—YOOK* |
| You and your wife are good. | *IG—vee—lo ahng—e—NOO—lo pee—oo—YOOK* Note the syllable *LO* is added to both words when the two are joined by *AND*. Thus the expression for *SNOW AND ICE* would be see—ko—lo ah—pud—lo |
| Your food is good | *NER—key pee—oo—YOOK* |
| Goodbye! | *Tug—VAH—oo—tit* |



# INDEX

**Detailed maps of the Far Northern areas of the Western Hemisphere are in the flap on the back cover of this manual.**

**A glossary of ice terms is on pages 3-4 to 3-10.**

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(AP-2) ALASKA
AERONAUTICAL PLANNING CHART
ALASKA
ARCTIC OCEAN
EAST SIBERIAN SEA
CHUKCHI SEA
BEAUFORT SEA
RUSSIAN SOVIET FEDERATED SOCIALIST REPUBLIC
U S S R
SEA OF OKHOTSK
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BROOKS RANGE
MACKENZIE MOUNTAINS
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(AP-3) CANADA
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